

Side Curtain Air Bag Investigation
Dynamic Science, Inc. (DSI), Case Number DS08021
2006 Ford Explorer
Washington
June 2008

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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.

1. Report No. DS08021	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Side Curtain Air Bag Investigation			5. Report Date May 19, 2009	
			6. Performing Organization Report No.	
7. Author(s) Dynamic Science, Inc.			8. Performing Organization Report No.	
9. Performing Organization name and Address Dynamic Science, Inc. 299 West Cerritos Avenue Anaheim, CA 92805			10. Work Unit No. (TRAIS)	
			11. Contract or Grant no. DTNH22-07-00045	
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NVS-411) National Highway Traffic Safety Administration 1200 New Jersey Ave, SE Washington, DC 20590			13. Type of report and period Covered [Report Month, Year]	
			14. Sponsoring Agency Code	
15. Supplemental Notes				
16. Abstract This on-site investigation focused on the deployment of the side curtain air bags in a 2006 Ford Explorer that was involved in a two vehicle crash and subsequent two quarter turn rollover. The crash occurred within a four-leg intersection. The Ford was being driven by a restrained 47-year-old male. The Ford was struck on the right side while making a left turn by a 1998 BMW 740 sedan. The subject vehicle was displaced in a counterclockwise rotation, tripped, and overturned with its left side leading. The Ford rolled two quarter turns and came to rest on its roof. The driver sustained a minor laceration to his left wrist. The Ford was towed from the scene due to damage and was later declared to be a total loss by the insurance company.				
17. Key Words Side curtain air bag, rollover, minor injury			18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price	

Dynamic Science, Inc.
Crash Investigation
Case Number: DS08021

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BACKGROUND

This on-site investigation focused on the deployment of the side curtain air bags in a 2006 Ford Explorer (**Figure 1**) that was involved in a two vehicle crash and subsequent two quarter turn rollover. The crash occurred within a four-leg intersection. The Ford was being driven by a restrained 47-year-old male. The Ford was struck on the right side while making a left turn by a 1998 BMW 740 sedan. The subject vehicle was displaced in a counterclockwise rotation, tripped, and overturned with its left side leading. The vehicle rolled two quarter turns and came to rest on its roof. The driver sustained a laceration to his left wrist. The Ford was towed from the scene due to damage and was later declared to be a total loss by the insurance company.



Figure 1. 2006 Ford Explorer

This crash was identified by a National Automobile Sampling System (NASS) researcher in a review of vehicles at an auto salvage facility. On July 3, 2008, DSI was sent photographs of the subject vehicle with instructions to obtain permission to inspect the vehicle. On July 8, 2008, DSI obtained a copy of the police report and received permission to inspect the subject vehicle. Field work was completed on July 19, 2008.

SUMMARY

Crash Site

This two-vehicle crash occurred in June 2008 at 2043 hours in the state of Washington. The weather was clear to partly cloudy, the asphalt roadway was dry, and no unusual conditions were present. The roadway character was straight and level. The crash scene was within an interchange area, west of a freeway overpass. The interchange consisted of an undivided, two-way east/west roadway, with interstate highway on/off-ramps intersecting the roadway on the north and south sides. The roadway consisted of two lanes each for east and westbound traffic. The inboard westbound lane was designated as left turn only as it approached the intersection. The intersection was controlled by three phase traffic signals. Vehicles turning left onto either the north or southbound on-ramps were required to yield to through traffic. The posted speed for the east/west roadway was 25 mph (40 kmph).



Figure 2. Westbound approach for the Ford

Pre Crash

The Ford was stopped in the left turn lane, heading west; the driver was waiting for through traffic to clear, and was intending to turn left and proceed south onto the interstate on-ramp (**Figure 2**). The 1998 BMW 740 sedan was being driven by a restrained 30-year-old male who was traveling eastbound in the outboard lane at an unknown speed (**Figure 3**).



Figure 3. Eastbound approach of the BMW

Crash

The Ford turned left across the path of the BMW, and the front end of the BMW impacted the right side of the Ford. The Missing Vehicle routine of the WinSmash program computed a Total Delta-V of 22 km/h (14.0 mph), based on the Ford's right side crush profile. The longitudinal and lateral components were -14 km/h (-8.4 mph) and -17 km/h (-10.0 mph). After the initial impact, the Ford was displaced in a counterclockwise rotation. The Ford tripped into a left side leading rollover and rolled two quarter turns.

Post Crash

The Ford came to rest on its roof on the southeast corner of the intersection, heading southeast. The BMW came to rest on the south roadway edge of the eastbound lane, heading southeast.

The driver of the Ford sustained a laceration to his left wrist. He unlatched his safety belt and exited the vehicle under his own power through the driver's door. The driver of the BMW was not injured. The Ford was towed from the scene due to damage and was later declared to be a total loss by the insurance company. The BMW was towed from the scene due to damage.

Vehicle Data - 2006 Ford Explorer

The 2006 Ford Explorer was identified by the Vehicle Identification Number (VIN): 1FMEU73E76Uxxxxxx. The vehicle's odometer could not be read due to the absence of power to the vehicle. The Ford was a 4-door sport utility vehicle that was equipped with a 4.0 liter, 6-cylinder engine, an automatic transmission, front/rear disc brakes with ABS, 4-wheel drive, power steering, and a tilt steering wheel. The Ford was configured with adjustable foot controls that were adjusted to the full rearward position. The driver was not aware that foot controls could be adjusted. The Ford was configured with Toyo A/T P235/70R16 tires. The vehicle manufacture's recommended cold tire pressure was 241 kPa (35 psi); the tire manufacturer's maximum pressure was 241 kPa (35 psi).

The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	290 kPa (42 psi)	7 mm (9/32 in)	No	None
LR	276 kPa (40 psi)	9 mm (11/32 in)	No	None
RR	Tire flat	4 mm (5/32 in)	No	Tire debanded
RF	262 kPa (38 psi)	7 mm (9/32 in)	No	None

The seating in the Ford was configured with front bucket seats with adjustable head restraints, a second row 60/40 split bench rear seat with folding backs and outboard seat head restraints, and a third row split bench seat with adjustable head restraints. The driver's seat was adjusted to the full rear track position. The seat back was reclined 15 degrees from vertical and the seat cushion angled 14 degree angles from the horizontal. The third row seat was in the stowed (cargo) position at the time of the vehicle inspection.

Vehicle Damage

Exterior Damage

The Ford sustained moderate damage from the impact with the BMW and the rollover.

The damage to the right side was the result of the impact with the BMW (**Figure 4**). The direct damage began 16 cm (6.3 in) forward of the rear axle and extended 270 cm (106.3 in) forward along the right side plane. The damage was concentrated low along the sill area. The field L began 10 cm (3.9 in) forward of the rear axle and extended 278 cm (109.4 in) forward along the right side plane. Six crush measurements were taken at the sill level as follows: C1 = 0 cm, C2 = 6 cm (2.4 in), C3 = 10 cm (3.9 in), C4 = 16 cm (6.3 in), C5 = 5 cm (1.9 in), C6 = 0 cm. The maximum crush was located at C4. The CDC for the impact with the BMW was 02RZEW2.



Figure 4. Right side damage

There was damage to the top and the left side planes from the rollover event (**Figures 5-6**). There was 317 cm (124.8 in) of direct contact along the left side that began 64 cm (25.1 in) forward of the front axle and extended rearward to include the left fender and left side doors. The damage extended vertically 91 cm (35.8) to the middle of the doors from the left roof side rail. There was direct damage to the hood that was 157 cm (61.8 in) wide and extended rearward 88 cm (34.6 in) rearward from the hood edge. The damage was 124 cm (48.8 in) wide across the roof and extended 104 cm (40.9 in) rearward from the windshield header edge. Both luggage rails were cracked. The maximum vertical crush to the left roof was located 29 cm (11.4 in) from the left side rail, and

measured 12 cm (4.7 in) vertically. The Collision Deformation Classification (CDC) for the rollover event was 00TDYO3.

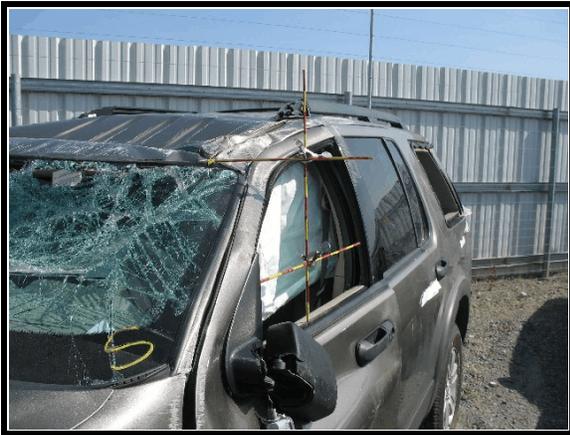


Figure 5. Maximum vertical crush



Figure 6. Rollover damage to top

Interior Damage

The Ford sustained moderate interior damage as a result of passenger compartment intrusion. There was vertical intrusion into the passenger compartment from both A-pillars, the roof, the windshield header, and the roof side rails (**Figure 7**).

All the doors remained closed and operational. The left front and third row left side windows, and the backlight disintegrated during the rollover. There was also impact damage to the windshield from the rollover.

The specific passenger compartment intrusions were documented as follows:



Figure 7. Overview of intrusion

Position	Intruded Component	Magnitude of Intrusion	Direction
Front row left	A-pillar	16 cm (6.2 in)	Vertical
Front row left	Roof side rail	13 cm (5.1 in)	Vertical
Front row right	A-pillar	12 cm (4.7 in)	Vertical
Front row right	Roof	10 cm (3.9 in)	Vertical
Front row left	Windshield header	9 cm (3.5 in)	Vertical
Front row left	Roof	9 cm (3.5 in)	Vertical
Front row right	Roof side rail	6 cm (2.4 in)	Vertical

Manual Restraints

The Ford was configured with 3-point manual lap and shoulder belts for all the seating positions. Both front seat safety belts were equipped with buckle pretensioners and adjustable D-rings that were in the full up position. The driver's seat belt pretensioner actuated during the rollover. The stalk of the buckle pretensioner compressed 4 cm (1.6 in). The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). There were no indications of loading to the safety belt.

The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR).

Supplemental Restraint Systems

The Ford was equipped with advanced occupant protection systems including multi-stage Certified Advanced 208-Compliant driver and front right passenger air bags. The multi-stage air bags were certified by the manufacturer to be compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Ford was also equipped with seat mounted side air bags. The frontal and the seat mounted side air bags did not deploy.

The Ford was also equipped with the Ford Safety Canopy System. The system consists of an inflatable nylon curtain with a gas inflator concealed behind the headliner and above the doors.

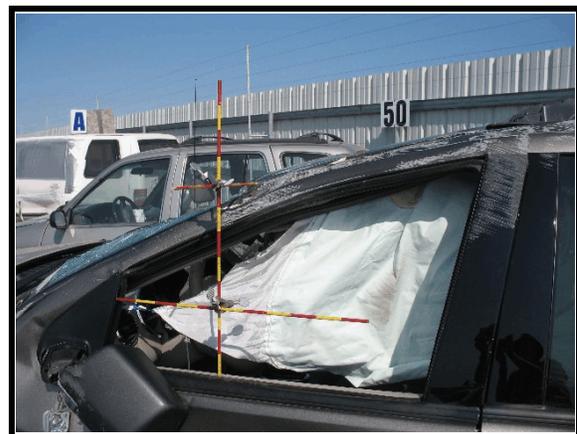


Figure 8. Damage to curtain exterior

The headliner flexed open above the side doors to allow for the deployment. Two side crash sensors were mounted within the front doors, two side crash sensors were located at the C-pillars behind the rear doors, and a rollover sensor was contained within in the Restraints Control Module (RCM). The system actuated when the vehicle experienced lateral deceleration sufficient at the threshold or when the rollover event was detected by the rollover sensor.



Figure 9. Contact to interior portion of curtain

The side curtain air bags deployed during the rollover. This was evidenced by the lack of the seat bags deploying. The side curtain air bags were 142 cm (55.9 in) in length and were 48 cm (18.9 in) high. The air bags provided coverage for both the first and second rows of the vehicle. The bottom of the air bag extended to 2 cm (0.8 in) below the side window frames. The front aspect of the air bag was attached in the front to the A-pillar by an 11 cm (4.3 in) tether that was configured in a triangle-shaped sail that was stitched to the air bag. The rear aspect of the air bag was attached to the C-pillar by a 1.5 cm (0.6 in) tether.

The outboard aspect of the side curtain air bag at the driver's position sustained two areas of abrading contact with the roadway surface (**Figure 8**). The larger contact was located 22 cm (8.7 in) from the leading edge of the air bag and was 8-10 cm (3.1-3.9 in) wide by 30 cm (11.8 in) high. The smaller contact was located at 9 cm (3.5 in) from the front edge of the air bag and was approximately 2 cm (0.8 in) wide by 17 cm (6.7 in) high.

There was a possible occupant contact from the driver located on the inboard aspect of the air bag at the driver's position (**Figure 9**). The contact was a dark linear transfer that measured 6 cm (2.4 in) high by 5 cm (1.9 in) wide and was located 10 cm (3.9 in) from the top of the curtain and 27 cm (10.6 in) rear of the front edge of the curtain.

Rollover Dynamics

The Ford had a Static Stability Factor (SSF) of 1.13 and a New Car Assessment Program (NCAP) Rollover Resistance Rating (RRR) of three stars, indicating that it had a 22 percent chance of rollover. The RRR is an estimate of the risk of rolling over if a single vehicle is tripped by a curb, ditch or soft soil. It does not predict the likelihood of that crash. The RRR is based on the SSF, a measure of a vehicle's center of gravity and track width, to determine how top-heavy the vehicle is. The Ford was equipped with AdvanceTrac stability control and Roll Stability Control (RSC) which were standard equipment for this model year. According to Ford literature, the system uses a gyro sensor to calculate the vehicle's roll speed and angle, and if it determines that a rollover is imminent, the system employs countermeasures that include applying brake force at one or more tires and reducing engine power.

The Ford was making a left turn when it was impacted on the right side by the BMW. The Ford was displaced in a counterclockwise rotation. There were gouges to both the left front and left rear rims,

which indicated that there was stress on the tires. As the Ford moved laterally left, it tripped and began a left side leading rollover. The vehicle rolled two quarter turns and came to rest on its roof in the northwest area of the intersection. The estimated distance between the trip point and final rest was 5 m (16.4 ft). There was insufficient time or distance for the RCS countermeasures to have any effect on the driver's ability to regain control of the vehicle.

Vehicle Data - 1998 BMW 740IL

The 1998 BMW 740IL was identified by the VIN: WBAGJ8320WDxxxxxx. The BMW was a 4-door sedan that was equipped with a 4.4 liter, 8-cylinder engine, automatic transmission, and front wheel drive. The vehicle was being driven eastbound at an unknown speed. The vehicle sustained front damage during the crash and was towed from the scene.

OCCUPANT DEMOGRAPHICS

	Driver
Age/Sex:	47/Male
Seated Position:	Front left
Seat Type:	Bucket
Height:	188 cm (74 in)
Weight:	118 kg (260 lbs)
Alcohol/Drug Involvement:	None
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, unknown clock position
Foot Position:	Right foot on accelerator, left foot on floor
Restraint Usage:	Lap and shoulder belt used
Air bag:	Frontal and seat mounted side air bags did not deploy. Side curtain air bag deployed.

OCCUPANT KINEMATICS

Driver Kinematics

The 47-year-old male driver was seated forward facing and was restrained by the 3-point manual lap and shoulder belt. The seat was adjusted to the rear most track position. Both hands were on the steering wheel and his right foot was on the accelerator. The driver was attempting a left turn. At impact with the BMW, the driver initiated a right lateral and slightly forward trajectory. He was held in place by the lap and shoulder belt. The Ford began a counterclockwise rotation and the

driver was displaced slightly to the right. As the Ford tripped and began its left side leading rollover, the side curtain air bags deployed and the driver's seat belt pretensioner actuated. He was held in place during the two quarter turn rollover, and possibly contacted the side curtain air bag. The driver sustained a minor laceration to the left wrist due to flying or broken glass. The driver unlatched his safety belt and exited the vehicle under his own power through the driver's door.

OCCUPANT INJURIES

Driver: Injuries obtained from interviewee.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Laceration, left wrist	790602.1,2	Flying glass	Probable

Attachment 1. Scene Diagram

