CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA08050

VEHICLE: 2006 FORD ESCAPE

LOCATION: ALABAMA

CRASH DATE: AUGUST 2008

Contract No. DTNH22-07-C-00043

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. CA08050	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Rollover Crash Investigation Vehicle: 2006 Ford Escape Location: State of Alabama		*5. Report Date*: October 2009 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* *11. Contract or Grant No.* DTNH22-07-C-00043	
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* Crash Date: August 2008 *14. Sponsoring Agency Code*	
15. Supplementary Note This on-site investigation focused on the rollover crash of a hybrid-powered 2006 Ford Escape.			
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17. Key Words Rollover crash		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 8	*22. Price*

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BACKGROUND

This on-site investigation focused on the rollover crash of a hybrid-powered 2006 Ford Escape **(Figure 1)**. The Ford was occupied by a 19-year-old male driver and a 14-year-old female front right passenger. The Escape was equipped with a high-voltage nickel-metal hydride battery pack with a total output rating of 300-volts. The hybrid battery was used for low-speed vehicle movement and to assist the 2.3-liter gasoline engine in higher speed movement. This battery pack was located in the rear center of the vehicle under the cargo area floor. This Escape was equipped with a regenerative braking system to charge the hybrid battery. A standard 12-volt battery was located in the engine compartment of the vehicle and powered the gasoline engine, lighting and accessories. The Escape was also equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, seat back-mounted side impact air bags, and Inflatable Curtain (IC) air bags with rollover sensing. The CAC system consisted of dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, buckle and retractor-mounted pretensioners, buckle switch sensors, and a front right occupant presence sensor. The manufacturer of the Escape has certified that this vehicle is compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The driver of the Ford was not injured in the crash; however, he was transported to a local hospital for observation and was released. The front right passenger sustained minor severity injuries and was transported by ground ambulance to a local hospital where she was treated and released.


Figure 1. 2006 Ford Escape.

This crash was identified during the routine sampling of police crash reports conducted by the General Estimates System (GES) of the National Highway Traffic Safety Administration (NHTSA). The Crash Investigation Division (CID) of the NHTSA forwarded the notification to the Special Crash Investigations (SCI) team at Calspan on October 3, 2008. Calspan SCI initiated follow-up investigation and established cooperation with the insurance carrier of the Ford and determined that the vehicle was available for inspection at an insurance auction facility. The CID subsequently assigned an on-site investigation October 6, 2008 due to the Agency's interest in rollover crashes. The on-site portion of the investigation was conducted on October 9, 2008.

SUMMARY

Crash Site

This crash occurred during the nighttime hours of August 2008 on the roadside of a four-lane north/south interstate. The travel lanes were surfaced with asphalt and at the time of the crash the weather conditions were reported as clear and the road surface was dry. The interstate was configured with the two travel lanes in each direction that were separated by a depressed grass median. The southbound lanes were bordered by asphalt shoulders. The shoulder on the east roadside was surfaced with asphalt and was approximately 0.9 meters (3 feet) in width. The west shoulder was surfaced with asphalt and was 3.1 meters (10.2 feet) in width. Three rows of rumble strips were cut into the west shoulder. The posted speed limit was 113 km/h (70 mph). The west roadside consisted of a 17.2 meter (56.4 feet) wide grass embankment. The down slope began at the end of the shoulder and extended 4.9 meters (16 feet) to an open concrete culvert. The open concrete culvert measured 1.3 meters (4.3 feet) in width. The Crash Schematic is included as **Figure 9** of this report.

Vehicle Data

2006 Ford Escape

The 2006 Ford Escape was manufactured in 08/05 and was identified by Vehicle Identification Number (VIN) 1FMCU95HX6K (production number deleted). The Ford was equipped with hybrid power-train that consisted of a high-voltage nickel-metal hydride battery pack with a total output rating of approximately 300-volts and 2.3-liter gasoline engine linked to a continuously variable transmission. The service brakes were power-assisted front and rear disc with antilock and electronic brake force distribution. Additionally, the Escape was equipped with a regenerative braking system to charge the hybrid battery system. The tires were Continental Contitrac on the front left, rear left, and rear right mounted on OEM five-spoke alloy wheels. The front right tire separated from the vehicle during the crash and was not available for inspection. The vehicle manufacturer recommended front and rear cold tire pressure was 241 kPa (35 PSI). The tire data at the time of the SCI inspection was as follows:

Position	Measured Pressure	Measured Tread Depth	Damage
Left Front	Tire Flat	5 mm (6/32 in)	De-beaded
Right Front	Unknown	Unknown	Unknown
Left Rear	Tire Flat	5 mm (6/32 in)	De-beaded
Right Rear	Tire Flat	4 mm (5/32 in)	De-beaded

The interior safety systems consisted of 3-point lap and shoulder belts for the five seating positions, a CAC frontal air bag system, buckle and retractor-mounted pretensioners, seat back-mounted side impact air bags, and IC air bags with rollover sensing.

Crash Sequence

Pre-Crash

The 19-year-old male driver was operating the 2006 Ford Escape southbound on the inboard lane with the cruise control set to 121 km/h (75 mph). The driver stated to the SCI investigator that while traveling southbound, he observed a large section of tire debris on the inboard lane. He applied a left steering input to avoid the debris and entered the grass median. The driver subsequently applied a right steering input in an attempt to regain the travel lane. The Ford reentered the roadway and initiated a clockwise yaw as it traversed the travel lanes and departed the west roadside **(Figure 2)**. The driver applied the brakes in an attempt to regain control of the Ford. It should be noted that two locked tire marks were present on the shoulder in the area of the crash site. The tread pattern of these marks was indicative of a vehicle in a near tracking attitude and was not consistent with the CW yaw of the Ford. Therefore, these marks were deemed to be unrelated to this crash.

Figure 2. Area of the right road departure.

Crash

The Ford entered the grass embankment area where the left tires rolled under the alloy wheels exposing the rim beads to the soft terrain. The rim beads gouged the ground which tripped the vehicle into a left side leading rollover event. The Ford rolled down the embankment and partially climbed the back slope of the embankment. The vehicle rolled over a total of four-quarter turns coming to rest on its wheels facing a westerly direction. The rollover sensor actuated the dual pretensioners and deployed both IC air bags. **Figure 3** is an overall view of the crash site.

Figure 3. Overall view of the embankment where the Ford rolled over.

Post-Crash

Police and emergency medical personnel responded to the crash site. The driver of the Ford exited the vehicle unassisted through the front left door. Although he was not injured in the crash, the driver was transported to a local hospital for observation and was released. The front right passenger was assisted through the front left door by the driver and a police officer. She sustained minor severity injuries and was transported by ground ambulance to a local hospital where she was treated and released. The Ford sustained moderate damage was towed from the crash site and was subsequently deemed a total loss by the insurance company.

Vehicle Damage

Exterior – 2006 Ford Escape

The Ford sustained moderate severity damage from this rollover crash **(Figure 4)**. The damage consisted of scattered abrasions throughout the sides and roof of the vehicle. In addition to the abrasions, the vehicle sustained multiple areas of isolated deformation. The top plane sustained the majority of the deformation with 8 cm (3.1 in) of maximum vertical crush and 5 cm (2 in) of maximum lateral crush occurring at the right A-pillar **(Figure 5)**. In addition to the crush, the windshield was fractured and the right front, rear door, and backlight glazing were disintegrated. The front left, front right, and the rear right alloy wheels were fractured near the base of the spokes. The rear left wheel was not damaged. The CDC assigned to this impact was 00-TDDO-3. The four doors remained closed during the crash. Post-crash, the left side, tailgate, and the rear right doors were operational. The front right door was jammed in the closed position.

Figure 4. Front right oblique view of the residual damage.

Figure 5. Location of maximum vertical and maximum lateral crush.

Interior – 2006 Ford Escape

The interior of the Ford consisted of leather surfaced five-passenger seating with front bucket seats and a rear bench seat with split folding backs. The five seating positions were equipped with adjustable head restraints. The front left and front right head restraints were adjusted to 8 cm (3.3 in) and 3 cm (1 in) above the full-down positions, respectively. The front left seat back was reclined to a measured angle of 30 degrees with the seat track adjusted to the full-rear track position. The front right seat back angle was 50 degrees aft of vertical and the seat track was adjusted to the full-rear position. The position of the front seats was confirmed by the driver during the interview. **Figure 6** is an overall view of the front row.

Figure 6. Overall view of the front row.

The interior of the Ford sustained minor severity damage as a result of passenger compartment intrusion and occupant contact points. A single contact point was present which consisted of an 8 cm x 3 cm (3 in x 1 in) scuff mark on the left aspect of

retractable sun roof shade. The passenger compartment intrusions are listed in the following table:

Position	Component	Magnitude	Direction
Front Right	Roof	4 cm (1.5 in)	Vertical
Front Right	Roof side rail	6 cm (2.5 in)	Vertical
Rear Center	Roof	6 cm (2.5 in)	Vertical
Rear Right	Roof	8 cm (3 in)	Vertical

Hybrid Vehicle Battery System – 2006 Ford Escape

The 2006 Ford Escape Hybrid was equipped with a hybrid battery system used to drive an electric motor that assists the gasoline engine. This system improves fuel efficiency while the gasoline engine is in use, or to provide power for vehicle movement at lower speeds without the use of the gasoline engine. The hybrid battery was manufactured by Sanyo and consisted of 250 cells in 50 modules. It has a nominal voltage of 300-V with a capacity of 5.5-Ah using nickel-metal hydride cells and a potassium hydroxide electrolyte. The hybrid battery was located centered under the cargo area of the vehicle. The hybrid battery system was not damage during the crash.

Figure 7. Hybrid battery, located in the floor of the cargo area.

Frontal Air Bag System – 2006 Ford Escape

The Ford was equipped a CAC frontal air bag system. The CAC system consisted of dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, buckle and retractor-mounted pretensioners, buckle switch sensors, and a front right occupant presence sensor. The manufacturer of the Escape has certified that this vehicle is compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bag system did not deploy during this rollover crash.

Side Impact and Rollover Air Bag System – 2006 Ford Escape

The Ford was equipped with seat back-mounted side impact air bags and roof rail-mounted IC air bags with rollover sensing. The seat back-mounted side impact air bags did not deploy during the crash. Both IC air bags deployed during the rollover crash sequence **(Figure 8)**. The curtain air bags were 150 cm (59 in) in length and 43 cm (17 in) in height. The IC did not provide full coverage across the side glazing of the Ford. A triangular shaped void that measured 33 cm (13 in) in height and 36 cm (14

Figure 8. Deployed right IC air bag.

in) in width was present at the forward aspect of the IC's. Vertically, a 3 cm (1 in) gap was present between the IC's and the beltline. Rope-type tethers were used to tether the IC's to the A- and C-pillars. These tethers were cut post-crash by rescue personnel. There was no damage or occupant contact points to the IC's.

Safety Belt Systems – 2006 Ford Escape

The Ford was equipped with manual 3-point lap and shoulder belts for the five seat positions. The five belt systems utilized continuous loop webbing and sliding latch plates. The driver's belt retracted onto an Emergency Locking Retractor (ELR) and was equipped with a buckle-mounted pretensioner and a retractor-mounted pretensioner. The driver used the safety belt at the time of the crash, which was supported by the loading evidence on the belt system. The loading consisted of full width frictional abrasions to the latch plate.

The front right and the second row safety belt systems utilized continuous loop webbing and switchable ELR/Automatic Locking Retractor (ALR). The front right belt system was also equipped with dual pretensioners which actuated during the crash. The front right passenger utilized the safety belt during the crash. Loading abrasions were noted on the latch plate which supported the usage by the front right passenger.

Driver Demographics

Age/Sex:	19-year-old/Male
Height:	180 cm (71 in)
Weight:	79 kg (175 lb)
Seat Track Position:	Full-rear
Safety Belt Usage:	Lap and shoulder belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Self extricated
Mode of Transport from Scene:	Ground Ambulance
Type of Medical Treatment:	Evaluated and released

Driver Injuries

Injury	***Injury Severity (AIS 90/ Update 98)***	***Injury Source***
Not injured	N/A	N/A

Source: Driver interview

Driver Kinematics

The 19-year-old male driver of the Ford was seated in the front left seat and was restrained by the manual lap and shoulder safety belt system. As a result of the right road departure, the vehicle tripped into a left leading four-quarter turn rollover event. At the onset of the rollover event, the dual pretensioners actuated and locked the safety against the driver and the IC air bags deployed. The driver loaded the belt system which allowed the driver to remain within the front left seating position. The combination of restraint use and the deployment of the safety system most likely prevented the driver from

sustaining injuries during the crash. The driver was not injured during the crash; however, he was transported to a local hospital for observation and was released.

Front Right Passenger Demographics

Age/Sex:	14-year-old/Female
Height:	163 cm (64 in)
Weight:	59 kg (130 lb)
Seat Track Position:	Full-rear
Safety Belt Usage:	Lap and shoulder belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Assisted through front left door
Mode of Transport from Scene:	Ground Ambulance
Type of Medical Treatment:	Treated and released

Front Right Passenger Injuries

Injury	***Injury Severity (AIS 90/ Update 98)***	***Injury Source***
Right ankle sprain	Minor (850206.1,1)	Floor
Right shoulder contusion, NFS	Minor (790402.1,1)	Shoulder belt
Right forearm abrasion (glass present), NFS	Minor (790202.1,1)	Flying glass
Left thigh abrasion (glass present), NFS	Minor (890202.1,2)	Flying glass
Small abrasions to the top and bottom of feet (glass present), NFS	Minor (890202.1,3)	Flying glass

Source: Driver interview

Front Right Passenger Kinematics

The 14-year-old female passenger of the Ford was seated in the front right seat and was restrained by the manual lap and shoulder safety belt system. The seat track was in the full-rear position with the seatback reclined to 50 degrees aft of vertical. The driver noted that the front right passenger was sleeping prior to the crash. Her pre-crash position created a substantial gap between her torso and the shoulder belt. The rollover event actuated the dual pretensioners locking the safety belt and the IC air bags deployed. The front right passenger responded to the rollover crash forces by initiating a lateral and vertical trajectory within the vehicle. She loaded the belt system which resulted in the shoulder contusion. During her motion, her right foot loaded the floor which resulted in the right ankle sprain. The ground contact disintegrated the side glazing which was dispersed throughout the vehicle. The passenger was contacted by the flying glass which resulted in the multiple soft tissue injuries. She was assisted out of the vehicle through the front left door by the driver and a police officer. The front right passenger was subsequently transported by ground ambulance to a local hospital where she was treated and released.

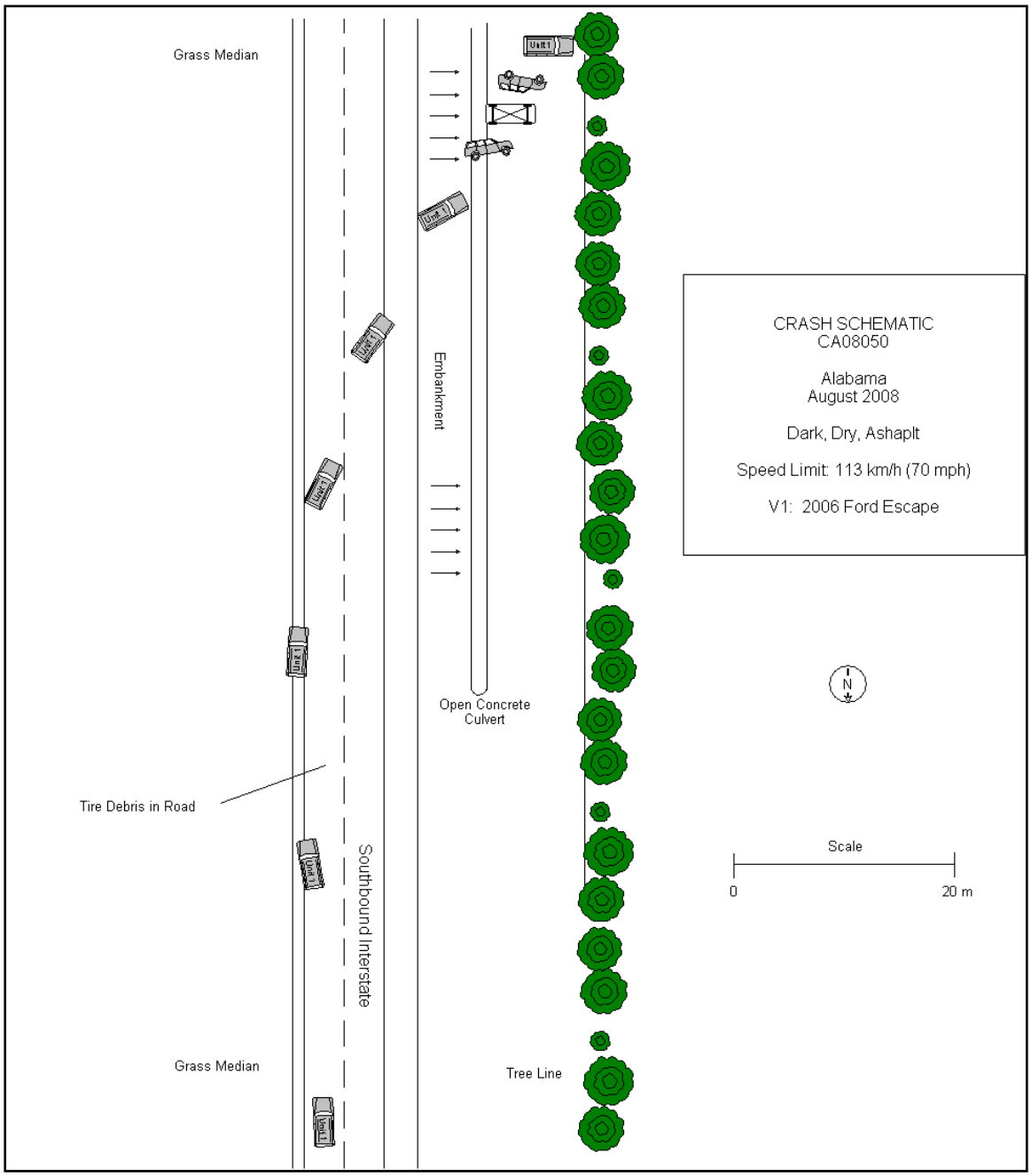

Figure 8. Crash Schematic