CRASH DATA RESEARCH CENTER

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CALSPAN REMOTE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA10006

VEHICLE: 2003 LINCOLN AVIATOR

LOCATION: COLORADO

CRASH DATE: 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 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 This remote investigation focused on the rollover of a 2003 Lincoln Aviator sport utility vehicle and the partial ejection of the restrained driver. The Lincoln was equipped with redesigned frontal air bags, Inflatable Curtain (IC) air bags with rollover sensing, and laminated front door glazing. The Lincoln was not equipped with Electronic Stability Control (ESC). The Lincoln was driven by a 62-year-old female driver. A 28-year-old female occupied the front right position and a 56-year-old male was seated in the rear right position. All occupants were police reported as restrained by the safety belt systems. The driver lost directional control of the vehicle as she traveled on a straight segment of road. The Lincoln departed the right road edge and subsequently overturned. The redesigned frontal air bags and the IC air bags deployed during the crash event.			
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TABLE OF CONTENTS

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BACKGROUND

This remote investigation focused on the rollover of a 2003 Lincoln Aviator **(Figure 1)** sport utility vehicle and the partial ejection of the restrained driver. The Lincoln was equipped with redesigned frontal air bags, Inflatable Curtain (IC) air bags with rollover sensing, and laminated front door glazing. The Lincoln was not equipped with Electronic Stability Control (ESC). The Lincoln was driven by a 62-year-old female driver. A 28-year-old female occupied the front right position and a 56-year-old male was seated in the rear right position. All occupants were police reported as restrained by the safety belt systems. The driver lost directional control of the vehicle as she traveled on a straight segment of road. The Lincoln departed the right road edge and subsequently overturned. The redesigned frontal air bags and the IC air bags deployed during the crash event.

Figure 1. Image of the Lincoln at final rest. (Image courtesy of the investigating police agency.)

The crash was identified through a review of rollover crashes in the Fatal Analysis Reporting System (FARS) by the National Highway Traffic Safety Administration's Crash Investigation Division. The Police Crash Report was forwarded to the Calspan Special Crash Investigations (SCI) team and was assigned for remote follow-up on September 23, 2009. This report was prepared following a review and an analysis of the police reported data and the on-scene images.

SUMMARY

Crash Site

This single vehicle rollover crash occurred off-road of a four-lane divided asphalt roadway in a rural setting during daytime hours. At the immediate location of the crash, the roadway was oriented in a north / south direction and was straight and level. Prior to the crash site, the roadway curved to the left for southbound travel. Both travel lanes were bordered by asphalt shoulders with rumble strips cut into the asphalt surface immediately outboard of the edge lines. The median was comprised of a dry dirt and grass surface that was depressed for drainage. The outboard (west) road edge consisted of a dirt and grass surface that sloped away from the shoulder. The roadside transitioned to a steep embankment that began approximately 9 m (30 ft) outboard of the shoulder edge. The down slope of the embankment was estimated at 30-40 degrees. A wire fence was located at the bottom of the embankment. A level dirt and grass area extended beyond the fence line with a single lane, dirt access road for a golf course extending parallel to the divided roadway. The posted speed limit of the divided roadway was 121

km/h (75 mph). At the time of the crash, atmospheric conditions were clear with dry road conditions. The crash schematic is attached to this report as **Figure 12.**

Vehicle Data

2003 Lincoln Aviator

The case vehicle in this crash was a 2003 Lincoln Aviator 4-door sport utility vehicle with all-wheel drive. The Lincoln was identified by Vehicle Identification Number (VIN): 5LMEU78H33Z (production number deleted). The Lincoln was powered by a 4.6-liter, V-8 engine linked to a 5-speed automatic transmission. The service brakes were power-assisted 4-wheel disc with antilock. The Lincoln was equipped with 43 cm (17 in) alloy wheels with Michelin all-season tires. Additional features included redesigned frontal air bags, IC air bags with rollover sensing, front safety belt buckle pretensioners, and laminated side glazing in the front doors. The Lincoln was equipped with a functional sunroof that was closed at the time of the crash.

The interior consisted of leather-surfaced front bucket seats with adjustable head restraints, a fixed center console/armrest, and a 3-passenger split-bench rear seat. All five seat positions were equipped with continuous loop safety belts with sliding latch places. The cargo area of the Lincoln contained miscellaneous loose objects at the time of the crash that included paper, pillows, a wooden chair and a wicker chair.

Crash Sequence

Pre-Crash

The driver of the Lincoln was traveling in a southerly direction in the left lane of the divided roadway at a police reported speed of 130 km/h (80 mph). The driver negotiated a sweeping left curve several hundred feet prior to the crash site. As she exited the curve, she allowed the vehicle to drift left across the rumble strips of the east shoulder and onto the dirt median surface for a distance of 36 m (118 ft) evidenced by the left front and left rear tire marks. During this trajectory, the driver initiated a right steering input that induced a clockwise (CW) yaw **(Figure 2)**. The left rear area of the Lincoln sideswiped a delineator post that was located outboard of the shoulder.

The Lincoln reentered the inboard shoulder and crossed the inboard southbound travel lane. The right front tire began to mark at the midpoint of the inboard travel lane and continued onto the outboard (right) shoulder. The Lincoln traveled a police reported distance of 43 m (140 ft) across the southbound travel lanes **(Figure 3)** during this CW yaw.

The driver counter steered left steering in an attempt to regain control of the Lincoln as it crossed the travel lanes. The left side tire marks merged as the vehicle entered the outboard shoulder. The left steering input reversed the vehicle's rotation **(Figure 4)** from CW to counterclockwise (CCW). The Lincoln continued to rotate CCW as it traversed the outboard shoulder and entered the dirt and grass roadside. The vehicle traveled a police reported distance of 21 m (69 ft) in the CCW yaw. The right side tires and wheels furrowed into the dirt surface as the Lincoln yawed approximately 40-50 degrees CCW.

Figure 2. Return to travel lanes following median departure.

Figure 3. CW yaw across travel lanes.

Figure 4. Lincoln reverses rotation from CW to CCW.

Figure 5. Right side tire furrows at trip point.

Crash

The furrowing of the right side tires **(Figure 5)** tripped the Lincoln into a right side leading rollover as its center of gravity continued down the negative sloped embankment that extended beyond the roadside. The rollover sensor deployed the IC air bags during the rollover. At the Lincoln rolled down the embankment, the frontal air bags deployed and the front safety belt buckle pretensioners actuated. The vehicle rolled a minimum of eight-quarter turns down the embankment and traveled through a wire fence before coming to rest in an upright position on the outboard edge of the dirt access road. The fence impact did not appear to alter the trajectory of the vehicle. The Lincoln came to rest 67 m (221 ft) from the initial trip point, facing in an easterly direction. The rollover was classified as a tripped/uninterrupted event.

Post-Crash

The driver was partially ejected through the left front door window opening during the rollover. She was removed from the vehicle and transported to a regional hospital where she expired approximately one hour after the crash. The front right passenger sustained a police reported incapacitating injury and the rear right passenger sustained a non-

incapacitating injury. Both passengers were transported to the regional hospital for treatment.

Vehicle Damage

Exterior

The exterior of the Lincoln sustained severe damage that was associated with the rollover. The rollover was initiated as a right side leading event. As the Lincoln continued to roll down the embankment, the rollover translated to an end-over type configuration. Maximum vertical crush was an estimated 30-36 cm (12-14 in) at the left A-pillar area with approximately 25 cm (10 in) of lateral displacement at the left A-pillar **(Figures 6 and 7)**. The left B-pillar was displaced laterally approximately 15-20 cm (6-8 in). This left roof side rail area of the Lincoln probably deformed during the third-quarter turn, or later in the rollover event.

Figure 6. Front left view of the rollover damage.

Figure 7. Vertical and lateral displacement at the left A-pillar area.

The upper left D-pillar was crushed downward and forward, indicative of end contact. The front left bumper area was also crushed rearward from ground contact. This contact possibly resulted in the deployment of the frontal air bags.

The four doors appeared to have remained closed during the crash event. Both front doors were opened post-crash to extricate the occupants. The left front door window frame was deflected outward. It is unknown if this displacement occurred during the rollover or resulted during the extrication efforts of the driver.

The laminated windshield was fractured and holed. The left half of the glazing panel was separated from the vehicle. The front door window glazing was laminated. The driver's door glazing was closed pre-crash and was cracked and out of place post-crash. The laminated glazing panel remained attached to the window track and was intact lying against the door panel. The right front door glazing was separated from the vehicle and was observed intact on the ground adjacent to the right side of the Lincoln. All other side and backlight glazing was disintegrated. The sunroof was closed pre-crash and was disintegrated.

Debris consisting of grass and dirt was present in the bead area of the right side wheels resulting from the initial furrowing and tripping of the vehicle. There was no significant wheel damage. The left front tire appeared to have been aired out while the left rear remained inflated. There was no left side wheel damage. The Collision Deformation Classification (CDC) for the rollover event was 00TDD05.

The Lincoln impacted and penetrated a wire fence at the bottom of the embankment. The specific body plane that struck the fence is unknown. There was no apparent damage to the vehicle from the fence impact. An estimated CDC for this event was 00U9999.

Prior to the rollover event, the left rear quarter panel area of the Lincoln sideswiped a delineator post. The resultant damage from this event was masked by the subsequent rollover event. The CDC for this initial impact event was 99LBES1.

Interior

The interior of the Lincoln was significantly reduced in size by intrusion of the roof side rails and roof structure. Maximum intrusion was located at the left upper A-pillar and involved both vertical and lateral displacement. The roof at the left A-pillar location was deformed downward and displaced laterally, buckling the roof panel over the front right passenger position. The left B-pillar was displaced laterally into the driver's seat back. The B-pillar trim panel and the overhead console separated from their mounting points. The left D-pillar and the backlight header were displaced forward during the rollover. Intrusion into the second row seat positions appeared to be minimal. **Figure 8** is an overall view across the interior from the right front door area.

Figure 8. View across the interior from the right front door area.

The lack of detailed interior images prohibited the identification of interior occupant contact points within the Lincoln. The driver was partially ejected through the left front window opening. Contact evidence that consisted of body fluid and tissue was present on the exterior surface of the left roof side rail and the deployed IC air bag. This contact evidence was also present of the inside surface of the left front laminate side glass.

Frontal Air Bag System

The Lincoln was equipped with redesigned frontal air bags for the driver and front right passenger positions. Both air bags deployed during the rollover crash. The driver's air bag was concealed within the steering wheel-mounted module by asymmetrical cover flaps. A seam of the driver's air bag appeared to have separated at the 8 o'clock position. There was no visible damage or occupant contact evidence to the driver air bag. The front right air bag was a mid-mount design and was concealed by a single cover flap. There was no apparent damage to the front right air bag.

The front safety belt systems utilized buckle-mounted pretensioners. Both front seat occupants were restrained by the safety belt systems and the pretensioners appeared to have actuated.

Inflatable Curtain Air Bag System

The Lincoln was equipped with roof side rail-mounted IC air bags with rollover and side impact sensing. The IC air bags were designed to deploy in both side impacts and rollover events. Both IC air bags deployed in this rollover crash.

The IC air bags were rectangular in shape and extended from the A- to the C-pillars. The air bags extended vertically to the beltline providing full vertical coverage of the side glazing. The forward edges of the IC air bags were tethered to the midpoint of the A-pillars. The IC's did not provide coverage of the triangle formed by the A-pillar in the area of the tether.

The on-scene images of the left IC air bag indicated the driver was partially ejected through the front left door window opening. The laminated side glass was cracked and out of place. The glazing remained attached to the track assembly and was lying on the side surface of the door panel. Body fluid associated with the partial ejection was present on the outside surface of the left IC at the midpoint of the door. The leading edge of the left IC was soiled and abraded from contact with ground during the rollover event. The left IC appeared to be captured between the intruding left B-pillar and the front left head restraint. The IC should have deployed prior to the displacement of the pillar; therefore the air bag was probably placed in this position during the extrication of the driver. The forward tether strap was separated from the air bag. It is unknown if this occurred during the rollover event or if the tether was cut during the extrication of the driver. **Figure 9** is an overall view of the deployed left IC air bag and the laminate side glazing.

The right IC air bag did not appear to be damaged or displaced by the rollover event. The right forward tether remained intact **(Figure 10)**.

Figure 9. Deployed left IC air bag and laminated side glazing.

Figure 10. Deployed right IC air bag.

Occupant Demographics/Data

Driver

Age/Sex:	62-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-track
Safety Belt use:	3-point lap and shoulder belt
Usage Source:	Police report, vehicle images
Ejection:	Partial ejection of the head through the left front door window opening
Egress from Vehicle:	Removed from vehicle by rescue personnel
Type of Medical Treatment:	Transported to a hospital where she expired one hour after the crash

Driver Injuries

Injury	**Injury Severity (AIS 90/Update 98)**	**Injury Source**
Head injury, NFS	Unknown (115099.7,0)	Roof side rail/ground

Source – Vehicle images

Driver Kinematics

The 62-year-old female driver of the Lincoln was seated in a mid track seat position with the head restraint adjusted to the full-down position. She was wearing the manual 3-point safety belt system. Belt usage was determined from the police report and the cut status of the belt webbing post-crash during the removal process of the driver.

Immediately prior to the rollover, the driver allowed the vehicle to drift to the left onto the median. She applied a series of right-left steering inputs as evidenced by the trajectory and yaw marks of the vehicle. The Lincoln departed the right road edge and tripped into a lateral right side leading rollover.

At the on-set of the rollover, the IC air bags deployed due to the roll sensing capability of the Lincoln. The IC air bags were tethered to the A-pillars and were rectangular in shape creating a void at the triangle formed by the A-pillar area. The IC air bags also extended vertically to the beltline providing full coverage of the side glazing. The laminated left front door glazing was closed.

As the vehicle rolled right, the driver would have responded by moving left with respect to the vehicle. The Lincoln completed a minimum of eight-quarter turns as it rolled down the embankment and penetrated the wire fence before coming to rest upright, 67 m (221 ft) from the trip point. During the rollover event, the redesigned frontal air bags deployed and the safety belt buckle pretensioners actuated.

Based on the evidence to the vehicle, the driver was partially ejected from the vehicle. Specifically, her head traveled through the glazing opening and was captured between the ground and the midpoint of the left roof side rail. Body fluid was present on the outboard

aspect of the deployed IC air bag at the midpoint of the door area and aft of the leading edge of the IC **(Figure 11)**. Body fluid was also present on the inside aspect of the side window glazing that remained attached to the track assembly, but was intact, cracked and out of place, lying against the door panel.

The driver was removed from the vehicle and was transported to a regional hospital where she expired approximately 1-hour post crash.

Figure 11. Driver contact evidence on the exterior of the left IC air bag and the left roof side rail.

Front Right Passenger

Age/Sex:	28-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-to-rear track
Safety Belt Use:	3-point lap and shoulder belt
Usage Source:	Police report, vehicle images
Ejection:	Not ejected
Egress from Vehicle:	Unknown
Type of Medical Treatment:	Transported to a regional hospital

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Unknown incapacitating injury	Unknown	Unknown

Front Right Passenger Kinematics

The front right passenger was seated in a mid-to-rear track position and was restrained by the manual safety belt system. The front right head restraint was set to the lowest adjusted position. Safety belt use was determined from the police report.

At the on-set of the rollover, the IC air bags deployed. During the rollover, the redesigned front right air bag deployed and the buckle pretensioner actuated. The restrained passenger loaded the safety belt and the deployed air bags during the rollover. There was insufficient interior documentation to determine specific points of contact within the interior. The IC air bag appeared to have prevented a partial ejection of the passenger's upper body and or upper extremities. She sustained police reported incapacitating injuries and was transported to a regional hospital for treatment.

Rear Right Passenger

Age/Sex:	56-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Fixed
Safety Belt Use:	3-point lap and shoulder belt
Usage Source:	Police report
Ejection:	Not ejected
Egress from Vehicle:	Unknown
Type of Medical Treatment:	Transported to a regional hospital

Rear Right Passenger Injuries

Injury	**Injury Severity (AIS 90/Update 98)**	**Injury Source**
Non-incapacitating injury	Unknown	Unknown

Rear Right Passenger Kinematics

The rear right passenger was police reported as restrained by the manual 3-point lap and shoulder belt system. He was seated in an unknown posture. The rear right head restraint was adjusted approximately 4-5 cm (1.5-2 in) above the seat back.

At the on-set of the rollover, the IC curtain air bags deployed. The right IC air bag provided coverage for the full width and height of the rear door glazing. During the rollover, the passenger loaded the safety belt system and probably contacted the deployed IC air bag. The right rear door glazing was disintegrated; therefore the IC air bag possibly prevented a partial ejection of the passenger's upper body, head, and or upper right extremity.

The rear right passenger sustained a police reported non-incapacitating injury and was transported to a regional hospital where he was treated for his injury.

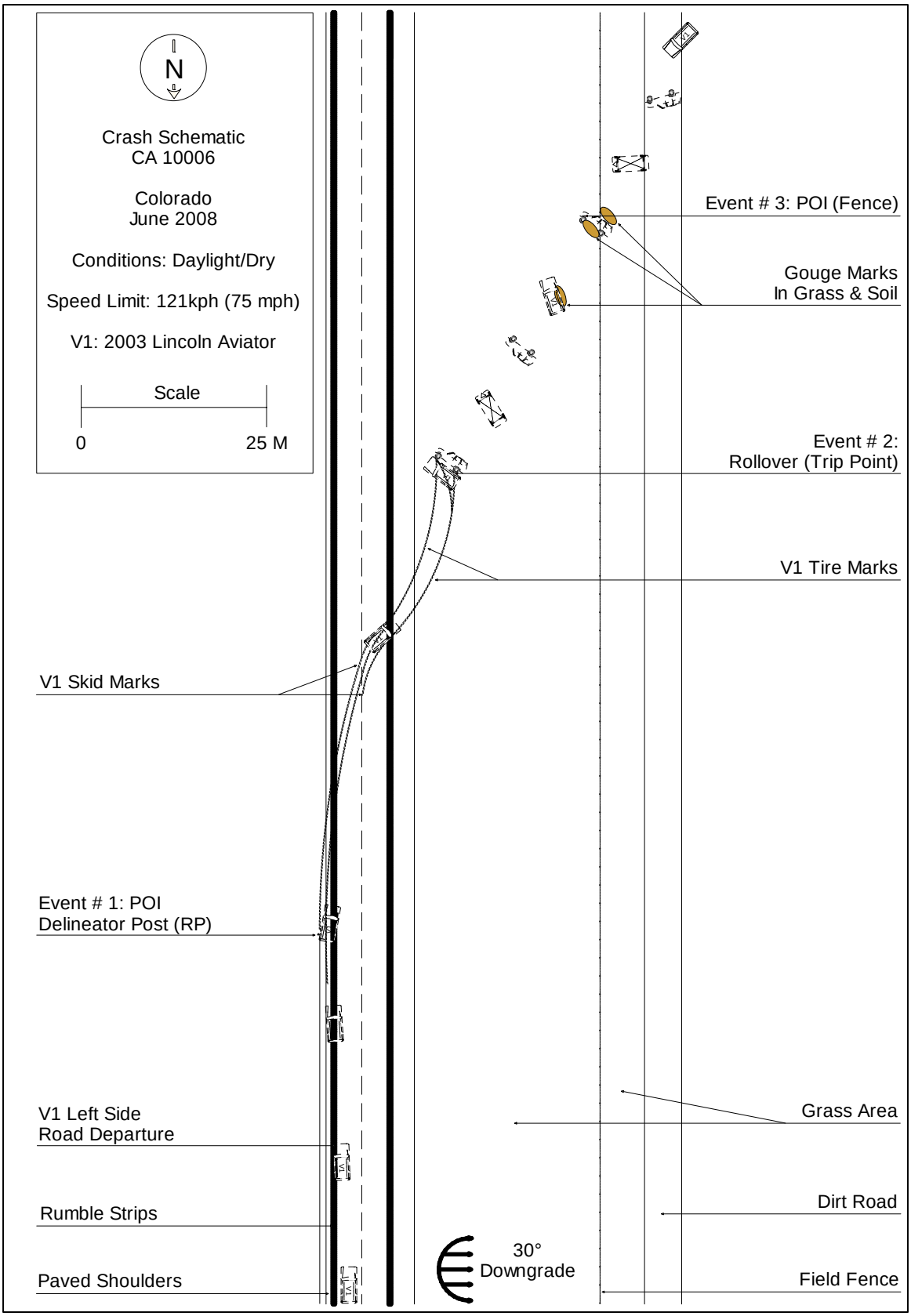

Figure 12. Crash Schematic