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CALSPAN REMOTE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA09061

VEHICLE: 2004 LINCOLN AVIATOR

LOCATION: ALABAMA

CRASH DATE: JUNE 2005

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration. 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 system.

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16. Abstract This remote investigation focused on the rollover of a 2004 Lincoln Aviator sport utility vehicle. The Lincoln was equipped with frontal air bags, Inflatable Curtain (IC) air bags with rollover sensing, and laminated glazing in the front doors. The Lincoln was involved in a single vehicle loss of control crash on a four-lane divided roadway in a posted 72 km/h (45 mph) speed zone. The driver lost directional control following an aggressive steering input that resulted in a counterclockwise (CCW) yaw. The Lincoln entered the depressed grass median and tripped into a right side leading rollover event. The frontal air bags deployed during the rollover event; however, the IC air bags did not deploy. The unrestrained 68-year-old female driver of the Lincoln was completely ejected from the vehicle and expired at the crash site. The crash was identified by the National Highway Traffic Safety Administration (NHTSA) through a review of rollover crashes from the Fatal Analysis Reporting System (FARS). The Police Crash Report was forwarded to the Calspan Special Crash Investigations (SCI) team and assigned for remote investigation on Friday, October 12, 2009. The reconstruction of this crash was based on an analysis of the police reported data and the on-scene images of the vehicle and crash site. The police agency provided authorization to the SCI team to publish the images in the SCI report.					
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CALSPAN REMOTE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA09061
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BACKGROUND

This remote investigation focused on the rollover of a 2004 Lincoln Aviator sport utility vehicle. The Lincoln was equipped with frontal air bags, Inflatable Curtain (IC) air bags with rollover sensing, and laminated glazing in the front doors. The Lincoln was involved in a single vehicle loss of control crash on a four-lane divided roadway in a posted 72 km/h (45 mph) speed zone. The driver lost directional control following an aggressive steering input that resulted in a counterclockwise (CCW) yaw. The Lincoln entered the depressed grass median and tripped



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

into a right side leading rollover event. The frontal air bags deployed during the rollover event; however, the IC air bags did not deploy. The unrestrained 68-year-old female driver of the Lincoln was completely ejected from the vehicle and expired at the crash site. **Figure 1** is an overall view of the Lincoln at final rest.

The crash was identified by the National Highway Traffic Safety Administration (NHTSA) through a review of rollover crashes from the Fatal Analysis Reporting System (FARS). The Police Crash Report was forwarded to the Calspan Special Crash Investigations (SCI) team and assigned for remote investigation on Friday, October 12, 2009. The reconstruction of this crash was based on an analysis of the police reported data and the on-scene images of the vehicle and crash site. The police agency provided authorization to the SCI team to publish the images in the SCI report.

SUMMARY

Crash Site

This rollover crash occurred on a four-lane divided roadway during the hours of dusk. The roadway was oriented in an east/west direction and the travel lanes were separated by a depressed grass median. In the vicinity of the crash site, the westbound travel lanes were straight and level. At the time of the crash, atmospheric conditions were clear and all travel surfaces were dry. The crash was confined to the westbound travel lanes and the depressed grass median. The westbound travel lanes were delineated by dashed white lane lines with a solid yellow fog line denoting the south edge of the travel lanes and a solid white fog line denoting the north edge of the travel lanes. A wide paved shoulder was located outboard of the north fog line and a narrow paved shoulder was located outboard of the south fog line. A dirt and grass roadside extended outboard of the north

shoulder. Several paved commercial driveways intersected the north shoulder in the pre-crash trajectory area of the Lincoln. A rumble strip was cut into the inboard shoulder adjacent to the median. Additional stabilization of the inboard shoulders involved crushed stone that bordered the outboard edges of the grass median. The depressed grass median contained embankments at both edges. The posted speed limit was 72 km/h (45 mph). The crash schematic is attached as **Figure 13**.

Vehicle Data

The case vehicle in this crash was a 2004 Lincoln Aviator, 4x2 sport utility vehicle. The 4-door Lincoln was identified by Vehicle Identification Number (VIN): 5LMEU68H34Z (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 four-wheel disc with antilock. The Lincoln was also equipped with OEM multi-spoke alloy wheels and 43 cm (17 in) all-season tires. Additional exterior features included a roof rack, sill-mounted step bars mounted between the A- and C-pillars, and a receiver-type trailer hitch. The front door glazing was laminated. The rear door glazing was equipped with an aftermarket deep window tint film that was applied to the interior surface of the glazing. It is unknown if the aftermarket tint was applied to the rear quarter windows and backlight (disintegrated). The Lincoln was not equipped with a sunroof.

The safety equipment consisted of Advanced Occupant Protection System (AOPS) with dual stage frontal air bags, IC air bags with rollover sensing, 3-point lap and shoulder safety belts for the six outboard positions, and front seat belt buckle pretensioners.

The interior was configured with leather-surfaced bucket seats for the first and second rows and a fold-down third row two-passenger bench seat. The third row seat was in the up (functional) position. All six positions were equipped with adjustable head restraints. The front row head restraints were adjusted above the level of the seat backs. The third row restraints were in the full-down positions. The images were insufficient to determine the position of the second row head restraints.

Crash Sequence

Pre-Crash

Prior to the crash, the Lincoln was traveling in a westerly direction on the outboard travel lane at a police estimated speed that was above the posted speed limit of 72 km/h (45 mph). The driver allowed the vehicle to drift to its right onto the paved shoulder (**Figure 2**). The Lincoln traversed the right shoulder at a shallow angle and the right side tires departed the paved surface onto the roadside. The driver initiated a counterclockwise (CCW) steering input in an attempt to regain the travel lane. The Lincoln initiated a CCW yaw as the right side tires remained on the roadside. The steering input redirected the vehicle back toward the travel lanes as it continued to yaw in a CCW direction. Based on the photographic documentation of the yaw marks, the left rear tire mark crossed the right front mark at the mid-point of the north shoulder, indicating the Lincoln had rotated approximately 30 degrees CCW prior to re-entering the westbound travel lanes.



Figure 2. Point of departure from the north shoulder.



Figure 3. CCW yaw marks across travel lanes.

The Lincoln crossed both westbound travel lanes (**Figure 3**) and exited the south shoulder onto the stone at the edge of the median. The investigating officer (IO) documented a length of 101.8 m (334.0 ft) for the right rear yaw mark, 37.2 m (122.0 ft) of the left rear yaw mark, and 67.1 (220.0 ft) of the right front yaw mark. The left front yaw mark originated in the middle of the outboard travel lane and was not documented by the IO. All four tire marks ended on the stone shoulder at the north edge of the grass median. The right side tires apparently aired out as the Lincoln exited the paved shoulder onto the stone (**Figure 4**). The alloy wheels engaged the dirt and stone surface and tripped the Lincoln into a right side leading rollover. At the trip point, the vehicle had rotated approximately 80 degrees CCW with respect to its path of travel and was rolling about its longitudinal axis. The Lincoln traveled over the depressed grass center median as the tires lost ground contact. At this early stage of the rollover, the front end of the Lincoln pitched downward.



Figure 4. CCW rotation of the Lincoln off the south shoulder to the trip point.



Figure 5. Initial contact with the median slope.

Crash

The initial contact with the positive sloped embankment at the south side of the median (**Figure 5**) involved the right front tire and wheel, the right front bumper corner and the undercarriage of the Lincoln. Three distinct gouge patterns originated in the grass and dirt surface and continued into the stone shoulder. This non-horizontal impact deflected the frontal structure laterally left and separated the front bumper fascia. The bumper beam and the radiator support were buckled from the lateral forces. The lateral deformation of the frontal structure resulted in a partial separation of the right front

fender. The initial ground impact probably deployed the frontal air bag system. There was no EDR data available to support the deployment time of the frontal air bags.

The initial impact with the median slope redirected the Lincoln's center of gravity from a southwesterly direction to a westerly direction and accentuated the CCW rotation. The Lincoln appeared to have rebounded from this impact as the rollover translated from a lateral roll to an end-over roll. The back plane of the Lincoln impacted the slope of the median as the vehicle pivoted on the back plane resulting in crush and direct contact damage across the entire width and height of the back surface. The extent of damage was biased to the right as the right D-pillar area was crushed in a forward and downward direction. The flow of damage also indicated the Lincoln was in a vertical attitude beyond 90 degrees of horizontal.

The Lincoln rolled clockwise from the back plane contact and about its longitudinal axis and impacted the median with its right side, completing its third-quarter turn. This contact point was supported by abrasions to the right roof side rail area, the lower aspect of the right front door, and the right side of the hood. The right front fender, although displaced outboard of its original position, was not damaged by the ground contact. The Lincoln subsequently returned to its wheels (4th-quarter turn) and came to rest approximately 24 m (80 ft) from the initial contact point with the median and traveled an estimated distance of 30 m (100 ft) from the trip point to final rest. At rest, the Lincoln was facing in a west, southwesterly direction (**Figure 6**). The rollover was classified as an uninterrupted event.



Figure 6. Final rest position of the Lincoln and the ejected driver.

The unrestrained driver was redirected rearward by the back plane contact and was subsequently ejected through the left rear quarter window opening, presumably during the second to third quarter turns of the rollover event. She came to rest forward of the Lincoln and was pronounced deceased at the scene of unknown injuries.

Vehicle Damage ***Exterior***

The exterior of the Lincoln sustained moderate severity damage to the right side and severe damage to the back plane during the rollover event. The Collision Deformation Classification (CDC) was 00TDDO4. The frontal plane sustained induced deformation from the right side contact and the left side of the Lincoln sustained minor contact damage from an unknown object.

The frontal structure of the Lincoln was displaced laterally left as a result of the initial right front corner impact with the median embankment. The impact buckled the radiator support and the bumper beam right of the vehicle's centerline (**Figure 7**). The inner structure of the right front fender was displaced laterally. The right front fender was

minimally damaged and had partially separated from the inner structure. The top mounted bolts pulled through the fender without causing induced damage to the fender. The impact separated the bumper fascia and the headlamp assemblies. The right edge of the hood was deflected downward and laterally left from ground contact.



Figure 7. Left lateral displacement of the frontal structure.

The right step bar that was mounted to the sill between the A- and the C-pillars was crushed laterally. The lower aspect of the right front door was crushed laterally with the direct contact damage located at the forward third of the door panel. The top aspect of the right door window frames at the side rail was abraded from contact with the stone shoulder that bordered the outboard edge of the median. The right rear door panel was not damaged below the level of the window frame.

The back of the Lincoln sustained severe damage that was biased to the upper right aspect of the D-pillar/backlight header juncture. The direct contact damage that consisted of abrasions and dirt and grass debris extended the full width of the rear bumper fascia and the backlight header. The upper right D-pillar was displaced forward and downward. The roof side rail between the C- and D-pillar was buckled and displaced downward from the back plane engagement. The right rear quarter panel was compressed forward and downward as a result of the back plane contact. The maximum vertical roof crush was located at the right D-pillar and was estimated at 20-25 cm (8-10 in). The upper D-pillar was displaced approximately 20 cm (8 in) forward. **Figures 8 and 9** are images of the damage to the back plane of the Lincoln.



Figure 8. Damage to the back plane of the Lincoln.



Figure 9. Close-up view of the crush to the right D-pillar area.

There was minor severity damage to the left side of the Lincoln that could not be attributed to this crash. A horizontally oriented abrasion was noted to the midline of the left rear door panel. A diagonally oriented pattern that resembled a guy wire impact originated at the dogleg of the right rear door/C-pillar area and extended upward to the left B-pillar.

All four doors remained closed during the crash. The hood appeared to have remained closed. The rear lift gate appeared to have been jammed in the closed position by exterior deformation.

The laminated windshield did not appear to be damaged from the crash. The front door glazings were laminated glass and were closed pre-crash. Based on the review of the on-scene police images, the front door glazing remained in place during the rollover crash. Although the door glazings were holed at the lower aft quadrants, numerous impact points were visible on the panels suggesting the windows were holed by rescue personnel post-crash to gain access to the vehicle.

An aftermarket deep window tint film was applied to the rear door glazing and possibly the rear quarter windows and backlight glazing. The left rear door glazing was closed and remained intact post-crash. The left rear quarter window, backlight, and right rear quarter window glazing was disintegrated during the crash. It is unknown if the left rear quarter window was disintegrated by body deformation or by the driver as she was ejected through this opening. The on-scene image of the Lincoln showed that the right rear door glazing was shattered and holed at the scene of the crash with the forward third portion of the glazing held in place by the aftermarket tint film



Figure 10. On-scene image of the status of the right rear door glazing.

(**Figure 10**). The glass fragments were held in place by the aftermarket film. Follow-up images of the vehicle at the tow yard showed that the entire door glazing had separated from the window frame. The Lincoln was not equipped with a roof window.

The left front tire remained inflated during the crash. The face of the alloy wheel was abraded and the bead area was minimally deformed. The left rear tire was inflated post-crash and there was no apparent damage to the tire or alloy wheel. Both right side tires were de-beaded from the alloy wheels. The bead area of the right front wheel appeared to have been deformed while the right rear wheel was undamaged. Several of the on-scene images of the Lincoln indicated the right front suspension was damaged or separated.

Interior

The interior photographic documentation of the Lincoln was limited to several views through the window openings. The only discernable occupant contact points involved the rearward deflection of the front left seat back, blood evidence on the third row left head restraint and the adjacent safety belt latch plate, and makeup-like transfers on the left roof side rail aft of the B-pillar and the headliner at the C-pillar area. Intrusion of the passenger compartment was limited to the second row right position and the third row seat positions. These intrusions involved vertical displacement of the roof, the right roof side rail, the right upper D-pillar and the back light header. The maximum intrusion was estimated at 20-25 cm (8-10 in) and involved the right D-pillar side rail juncture.

Frontal Air Bag System

The 2004 Lincoln was equipped with an Advanced Occupant Protection System (AOPS) that consisted of dual-stage frontal air bags, a front left seat track positioning sensor, and safety belt buckle pretensioners. The frontal air bag system deployed during the rollover crash event. The driver’s air bag deployed from a steering wheel-mounted module with H-configuration cover flaps. The front right air bag was a mid-mount configuration with a single top-hinged cover flap. The images were insufficient to determine driver contact with the deployed air bags.

Side Impact/Rollover Air Bag System

The Lincoln Aviator was equipped with roof side rail mounted IC air bags that were designed to deploy in both side impact and rollover crashes. The side impact crash sensors were mounted in the lower B- and C-pillars. The IC air bags did not deploy in this crash.

Manual Safety Belt Systems

The 2004 Lincoln was equipped with 3-point lap and shoulder belts at the six outboard seating positions. Based on images of an exemplar vehicle, all of the belt systems utilized continuous loop webbing and sliding latch plates. The driver’s belt retracted onto an Emergency Locking Retractor (ELR). The front belt systems were equipped with buckle pretensioners. These pretensioners did not actuate during the crash. The police report and the ejection of the driver supported the unrestrained status of the driver.

Occupant Data /Demographics

Driver

Age/Sex: 68-year-old/Female
Height: Unknown
Weight: Unknown
Seat Track Position: Unknown
Safety Belt Use: None
Usage Source: Police report, ejected status
Egress from Vehicle: Complete ejection
Type of Medical Treatment: None, expired at scene

Driver Injuries

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

Source – Police Report

Driver Kinematics

The 68-year-old female driver of the Lincoln was operating the vehicle under the influence of alcohol with a police reported BAC of 0.14. She was seated in an unknown track position with the head restraint adjusted approximately 3 cm (1 in) above the seat back. The driver was not restrained by the manual safety belt system. The lack of belt usage was determined from the police report and the ejection status of the driver.

Prior to the crash, the driver was traveling at a high rate speed. She allowed the Lincoln to drift to the right off the edge of the outboard shoulder and onto the roadside. The driver applied a CCW steering input in an attempt to regain directional control of the vehicle. The Lincoln yawed CCW across the travel lanes and tripped into a right side leading rollover in the median.

The rollover involved a vertical component to the event as the front of the vehicle pitched downward. The right front corner area of the Lincoln impacted the dirt embankment of the median resulting in the deployment of the frontal air bag system. The unrestrained driver probably responded to this event by moving laterally to her right. This impact redirected the Lincoln's center of gravity from a southwesterly direction to a westerly direction. The Lincoln rebounded in a rearward direction as the vehicle's rollover transitioned to an end-over-end.

The back plane of the Lincoln impacted the median resulting in a forward crush pattern across the backlight header. The driver responded to this impact by initialing a rearward trajectory. She loaded the front left seat back, deforming the seat back rearward. The driver traveled between the seat backs of the first and second rows and contacted the third row left head restraint and safety belt buckle. Blood evidence was present on these components (**Figure 12**).



Figure 12. Body fluid evidence of the third row left head restraint and latch plate.

The Lincoln apparently bounced from the rear impact and barrel rolled to its right coming to rest upright in the median. The driver was subsequently ejected through the left rear quarter window opening and was thrown in a westerly direction coming to rest in the median forward (west) of the final rest position of the vehicle. It is unknown if the driver was contacted by the Lincoln during the rollover event. She was pronounced deceased at the scene from unspecified injuries.

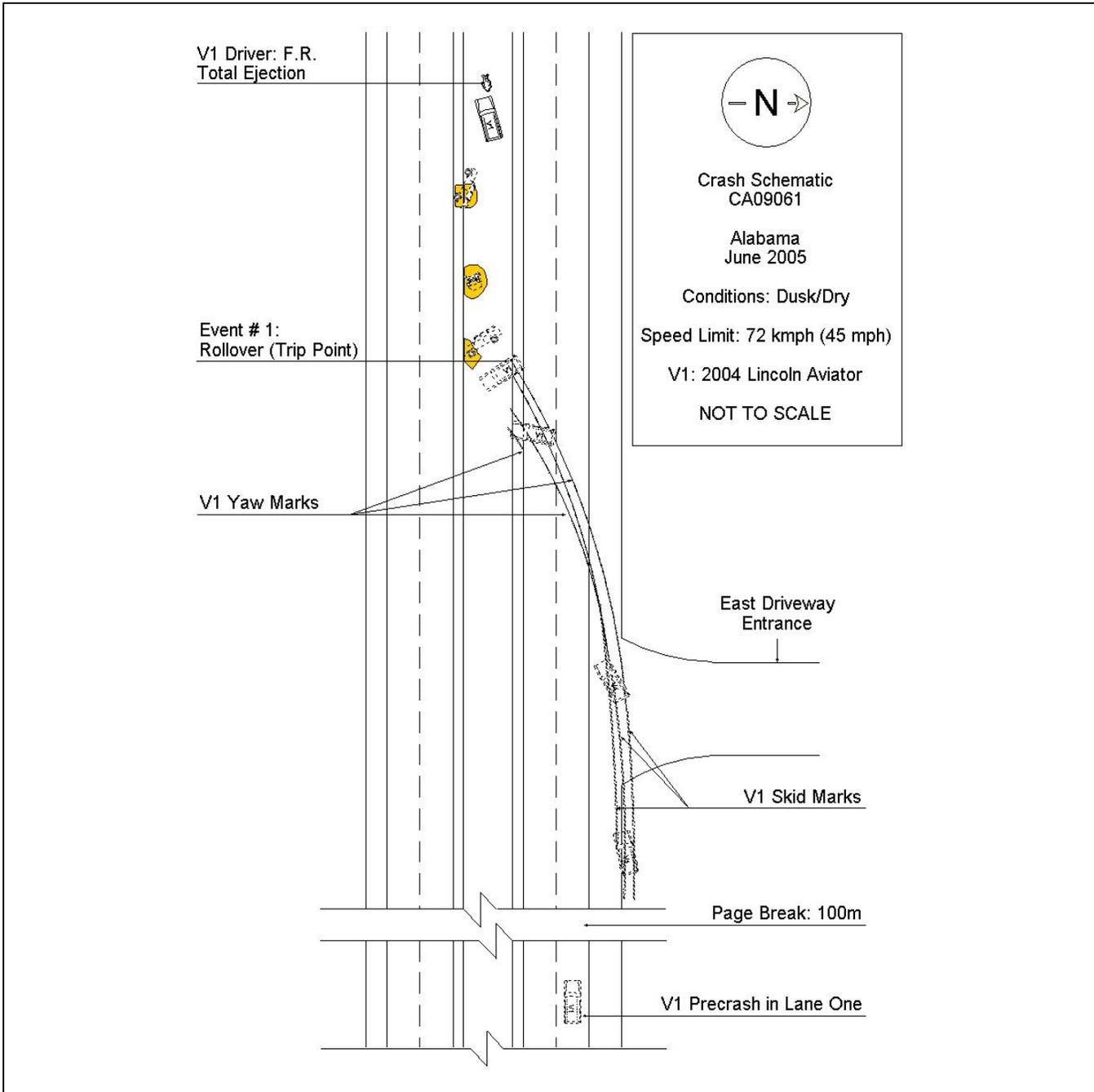


Figure 13. Crash Schematic.