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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN07007

LOCATION - INDIANA

VEHICLE - 2006 LINCOLN TOWN CAR

CRASH DATE - December 2006

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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.

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15. <i>Supplementary Notes</i> On-site child safety seat investigation involving a 2006 Lincoln Town Car equipped with manual safety belts, driver and front right air bag system and child safety seats installed in the back seat.					
16. <i>Abstract</i> This report covers an on-site child safety seat investigation that involved a 2006 Lincoln Town Car, which departed the roadway, impacted a fire hydrant and rolled over. This crash is of special interest because the case vehicle's back center passenger (13-month-old, female) was seated in an infant seat and was ejected from the infant seat during the crash sustaining a police reported B (non-incapacitating-evident) injury. The Lincoln was traveling south in the southbound lane in a left curve. The driver fell asleep and the vehicle departed the right side of the roadway, impacted a curb, and fire hydrant, rolled over passenger side leading, and the roof impacted a tree. The Lincoln then rotated clockwise off the tree and rolled back to the left and onto its wheels at final rest. The back center passenger was seated unrestrained in her infant seat and was ejected from the infant seat during the crash and came to rest in the right front floor area. She was transported to a hospital and was treated and released. Two other children were restrained in child safety seats in the back seat. They both sustained minor injuries.					
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TABLE OF CONTENTS

IN07007

Page No.

BACKGROUND 1

SUMMARY 1

CRASH CIRCUMSTANCES 2

CASE VEHICLE: 2006 LINCOLN TOWN CAR 4

 CASE VEHICLE DAMAGE 4

 AUTOMATIC RESTRAINT SYSTEM 7

 CHILD SAFETY SEATS 8

 CASE VEHICLE BACK CENTER PASSENGER KINEMATICS 10

 CASE VEHICLE BACK CENTER PASSENGER INJURIES 10

 CASE VEHICLE BACK LEFT PASSENGER KINEMATICS 11

 CASE VEHICLE BACK LEFT PASSENGER INJURIES 12

 CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS 12

 CASE VEHICLE BACK RIGHT PASSENGER INJURIES 13

 CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS 13

 CASE VEHICLE FRONT RIGHT PASSENGER INJURIES 14

 CASE VEHICLE DRIVER KINEMATICS 14

 CASE VEHICLE DRIVER INJURIES 15

CRASH DIAGRAM 16

This crash was brought to the National Highway Traffic Safety Administration's attention on or before December 20, 2006 by this contractor through a newspaper article. This crash involved a 2006 Lincoln Town Car, which departed the roadway, impacted a fire hydrant and rolled over. The crash occurred in December 2006, at 10:44 a.m., in Indiana and was investigated by the applicable city police department. This crash is of special interest because the Lincoln's back center passenger [13-month-old, female] was seated in an infant seat and was ejected from the infant seat during the crash sustaining a police reported B (non-incapacitating-evident) injury. Two other children were seated in child safety seats in the vehicle's back seat. This contractor contacted the owner of the Lincoln (i.e., a rental car company) in early January, but did not receive official permission to inspect the vehicle until March 1, 2007. This contractor inspected the Lincoln on March 5, 2007 and the scene on March 7, 2007. Permission to harvest the Restraint Control Module (RCM), which housed the Event Data Recorder (EDR) was denied by the owner on March 7, 2007. The investigating police officer was interviewed on March 12, 2007 and supplements of the police crash report were obtained. The Lincoln's driver was interviewed on March 29, 2007. The back center infant seat was held in evidence at the police department and was inspected on April 10, 2007. This report is based on scene, vehicle and child safety seat inspections, the police crash report, supplements to the police crash report, on-scene police photographs, inspection of an exemplar vehicle, an interview with the Lincoln's driver, occupant kinematic principles, occupant medical records and this contractor's evaluation of the evidence.

SUMMARY

The Lincoln was traveling south in the southbound lane in a left curve. The driver fell asleep and the vehicle departed the right side of the roadway, impacted a curb and fire hydrant, rolled over passenger side leading, and the roof impacted a tree. The Lincoln then rotated clockwise off the tree and rolled back to the left and onto its wheels at final rest. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry.

The CDCs for the Lincoln were determined to be: **12-FRWN-3** (0 degrees) for the right front wheel impact (event 1), **12-FRWN-9** (0 degrees) for the right rear wheel impact (event 2), **12-FZEN-1** (0 degrees) for the fire hydrant impact (event 3), **00-TYDO-4** for the rollover (event 4), and **00-TPDN-4** for the tree impact (event 5) that occurred during the rollover. The vehicle sustained 12 centimeters (4.7 inches) of residual maximum crush to the front bumper due to the fire hydrant impact. The WinSMASH reconstruction program calculated a Barrier Equivalent Speed (BES) for the fire hydrant impact of 14.6 km.p.h. (9.1 m.p.h.). The rollover crash severity was determined to be severe based on the roof crush. The crash severity for the tree impact to the top was also determined to be severe based on the roof crush. The Lincoln was towed due to damage.

The back center passenger (13-month-old, female) was seated in a Graco Assura rear-facing infant seat. The infant seat was manufactured by Graco Children's Products on September 26, 2005. The model number was 44106F0F. The back center passenger was seated in the infant

seat, but was not restrained by the internal five-point harness. The harness straps were found routed through the same slots in the infant seat's padded cushion as the lap belt. The harness retainer clip was also found positioned just above the buckled latch plates. The back center passenger was ejected from the seat during the crash and found on the right front floor by one of the investigating police officers. The back center passenger was transported to a hospital and treated and released. She sustained minor abrasions and contusions.

The Lincoln's back left passenger (6-year-old, male) was seated in a Graco TurboBooster booster seat. The booster seat was manufactured by Graco Children's Products on April 4, 2005. The model number was 8491RGB, and the serial number was JJ0414050806376. The back left passenger was restrained in the booster seat by the vehicle's lap-and-shoulder safety belt. The investigation indicated the shoulder belt was over the child's left shoulder and the lap belt was snug and across his hips. The back left passenger was transported by ambulance to a hospital and treated and released. He sustained contusions, abrasions and lacerations.

The Lincoln's back right passenger (3-year-old, male) was restrained in a Dorel Voyager belt-positioning booster seat. The booster seat was manufactured by the Dorel Juvenile Group on January 5, 2006. The model number was 22-211-WAL. The back right passenger was restrained in the booster seat by the vehicle's lap-and-shoulder safety belt. The investigation indicated the shoulder belt was over the child's right shoulder and the lap belt was snug and across his hips. The back right passenger was transported by ambulance to a local hospital and was treated and released. He sustained a left arm contusion and sore neck.

The Lincoln's driver (24-year-old, female) was restrained by her lap-and-shoulder safety belt. The driver was pregnant at the time of the crash and was transported by ambulance to a hospital and admitted overnight. Toxicology results indicated that the driver tested positive for marijuana. In addition, the driver stated to the investigating police officer that she had taken Ambien at 4:00 a.m. and Lortab at an unspecified time the morning of the crash. The driver sustained a nonanatomic brain injury due to contact with the roof and multiple abrasions and lacerations.

The Lincoln's front right passenger (9-year-old, female) was restrained by her lap-and-shoulder safety belt. She was transported by ambulance to a hospital and treated and released. The front right passenger sustained minor abrasions and a sprained left thumb.

CRASH CIRCUMSTANCES

The trafficway was a two-lane, undivided, city street, traversing in a general north-south direction. The southbound travel lane was 4.5 meters (14.8 feet) in width and the northbound travel lane was 4.8 meters (15.7 feet) in width. The roadway was bordered by barrier curbs and curved left in the southbound direction. There was also a hill crest prior to the area of roadway departure, and the pre-crash grade was negative 4.8%. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry bituminous. The estimated roadway coefficient of friction based on published references was 0.70. Traffic

density was light and the site of the crash site was residential. See the Crash Diagram at end of this report.

Pre-Crash: The Lincoln was traveling south in the southbound lane in a left curve (**Figure 1** below). The driver was intending to continue through the left curve. The front right passenger (9-year-old, female) stated to the investigating police officer that the driver fell asleep just prior to the crash. As a result, the vehicle departed the right side of the roadway (**Figure 2**) where the crash occurred. The vehicle's driver took no actions to avoid the crash. The police reported toxicology results indicated that the driver tested positive for marijuana. In addition, the driver stated to the investigating police officer that she had taken Ambien (sleeping aid) at 4:00 a.m and Lortab (pain reliever) at an unspecified time the morning of the crash.

Crash: As the Lincoln departed the right side of the roadway, the vehicle's front right wheel impacted the curb (event 1) and deflated, followed by the right rear wheel, which also deflated due to the curb impact (event 2). The vehicle crossed a sidewalk and the front (**Figure 3**) impacted a fire hydrant (event 3, **Figure 4**), which was located 3.4 meters (11.2 feet) west of the roadway. At this point, the roadside began to slope downward (38% negative grade, **Figure 5**) and the vehicle began to roll onto its right side (event 4). The vehicle rolled five quarter turns down the embankment traversing a distance of approximately 18 meters (59 feet) at which point the top (**Figure 6**) impacted a medium sized tree (event 5, **Figure 5**) located 12.7 meters (41.7 feet) west of the roadway. The vehicle then rotated clockwise off the tree and rolled back to its left and onto its wheels. The total rollover distance was approximately 21 meters (68.9 feet).

Post-Crash: The Lincoln was heading west at final rest. A passer-by notified authorities of the crash, and all the occupants were removed from the vehicle by rescue personnel.



Figure 1: Approach of Lincoln southbound to road departure (arrow), number on pavement indicates meters to fire hydrant impact



Figure 2: Area of Lincoln roadway departure, arrow shows impacted fire hydrant (repaired)



Figure 3: Overview of damage to front of Lincoln from fire hydrant impact (arrow) and rollover damage to roof



Figure 4: Location of impacted fire hydrant (repaired)



Figure 5: Lincoln rolled down embankment, impacted tree indicated by arrow, and came to final rest on its wheels on left side of tree

CASE VEHICLE

The 2006 Lincoln Town Car Signature was a rear wheel drive, four-door sedan (VIN: 1LNHM81V96Y-----) equipped with a 4.6L, V8 engine, four speed automatic transmission and four wheel anti-lock brakes. The vehicle's front row was equipped with a split bench seat with adjustable head restraints, driver and front right passenger lap-and-shoulder safety belt with pretensioners, a center seat lap belt, driver and front right passenger dual stage air bags and driver and front right passenger seat back-mounted side impact air bags. The second seat row was equipped with a bench seat with lap-and-shoulder safety belts in all three seating positions and integral head restraints in the outboard seating positions. The vehicle was also equipped with power adjustable pedals, traction control and a Lower Anchors and Tethers for Children (LATCH) system for securing child safety seats. The manufacturer of the Lincoln has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The vehicle's specification wheelbase was 299 centimeters (117.7 inches). The vehicle's odometer reading at the time of the inspection was unknown because the vehicle was equipped with an electronic odometer.



Figure 6: Damage to roof and right rear door due to impact with tree during rollover

CASE VEHICLE DAMAGE

Exterior Damage: The Lincoln's initial impacts to the curb involved the right front and right rear wheels (events 1 and 2). The impacts de-beaded both tires and slightly dented the right rear rim. The vehicle's impact to the fire hydrant (event 3) involved the right portion of the front bumper. The front bumper fascia, energy absorbing plastic and grille were broken; the right headlamp/turn signal assembly was displaced and missing, and the underlying bumper bar was crushed. The direct damage began 23 centimeters (9.1 inches) left of the right front bumper corner and extended

37 centimeters (14.6 inches) along the front bumper. The crush measurements were taken at the bumper bar located under the bumper fascia and energy absorbing plastic. The maximum residual crush was determined to be 12 centimeters (4.7 inches) occurring at C₆. The table below shows the vehicle's front crush profile.

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	3	37	12	146	0	3	6	7	10	12	15	0
in		14.6	4.7	57.5	0.0	1.2	2.4	2.8	3.9	4.7	5.9	0.0

The rollover damage involved both sides and the top (event 4). The impact with the tree (event 5), which occurred during the rollover, involved the top, right roof side rail, right rear door and the right quarter panel. The crush pocket caused by the tree impact was angled approximately 45 degrees to the left of the Lincoln's vertical axis. The maximum vertical and lateral crush (Figures 7, 8 and 9) to the top plane due to the rollover were 36 centimeters (14.2 inches) and 34 centimeters (13.4 inches), respectively. The maximum crush to the top plane from the tree impact was 33 centimeters (13 inches) and occurred near the back corner of the right rear door (Figures 7 and 9).



Figure 7: Left arrow shows location of maximum vertical and lateral crush due to the rollover; right arrow shows roof crush due to tree impact that occurred during rollover



Figure 9: Left arrow shows location of maximum lateral crush to the roof due to rollover; right arrow shows crush from tree impact that occurred during rollover



Figure 8: Left rear view of left roof side rail crush (arrow)

The Lincoln's right side wheelbase was reduced 2 centimeters (0.8 inch) while the left side wheelbase was unchanged. Induced damage involved the hood, roof, trunk lid and both quarter panels.

Damage Classification: The CDCs for the Lincoln were determined to be: **12-FRWN-3** (0 degrees) for the right front wheel impact (event 1), **12-FRWN-9** (0 degrees) for the right rear wheel impact (event 2), **12-FZEN-1** (0 degrees) for the fire hydrant impact (event 3), **00-TYDO-4** for the rollover (event 4), and **00-TPDN-4** for the tree impact (event 5) that occurred during the rollover. The WinSMASH reconstruction program could not be used on this crash because wheel impacts, yielding object impacts (i.e., the fire hydrant impact) and non-horizontal impacts (i.e., the rollover and tree impact) are out-of-scope for the program. However, the WinSMASH program was used to determine and Barrier Equivalent Speed (BES) for the fire hydrant impact based on the crush to the front bumper bar. The WinSMASH calculated the BES as: 14.6 km.p.h. (9.1 m.p.h.). The rollover crash severity was determined to be severe based on the roof crush. The crash severity for the tree impact to the top was also determined to be severe based on the roof crush. The Lincoln was towed due to damage.

The vehicle manufacturer's recommended tire size was P225/60R17. It was equipped with tires of this size. The vehicle's tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	228	33	221	32	7	9	None	No	No
RF	Flat	Flat	221	32	7	9	Tire de-beaded	No	Yes
LR	228	33	241	35	7	9	None	No	No
RR	Flat	Flat	241	35	7	9	Tire de-beaded	No	Yes

Vehicle Interior: Inspection of the vehicle's interior (**Figures 10-13**) revealed hair transfers on the roof over the driver's seat and scuffs in the nap of the roof over the back right seat position. Possible occupant contact scuffs were also observed on the back left arm rest. No other evidence of occupant contact was observed. Inspection of the safety belt assemblies revealed that the driver's safety belt and the back right passenger's safety belt had been cut by rescue personnel. The passenger compartment sustained severe intrusions due to the rollover and subsequent impact with a tree during the rollover. Intruding components included the roof, roof side rail and all the pillars. The most severe intrusion involved the roof structure at the back right seat position, which intruded approximately 37 centimeters (14.6 inches). There was no evidence of deformation to the steering wheel or compression of the energy absorbing steering column.



Figure 10: Overview of Lincoln driver's seat position and roof intrusion



Figure 11: Overview of Lincoln's front right seat position



Figure 12: Overview of Lincoln's back left seat position and roof intrusion



Figure 13: Overview of Lincoln's back right seat position and roof intrusion

AUTOMATIC RESTRAINT SYSTEM

The Lincoln was equipped with manufacturer certified advanced 208-compliant air bags at the driver and front right passenger positions. The driver's air bag was located in the steering wheel hub and the front right passenger's air bag was located in the middle of the instrument panel. Neither of these air bags or the driver and front right passenger safety belt pretensioners deployed in this crash. The Lincoln's advanced air bag system likely determined that the front impact with the fire hydrant was not severe enough to require an air bag deployment.

The Lincoln was also equipped with seat back-mounted side impact air bags, which were located in the outboard side of the front seat backs. The front right seat back-mounted side impact air bag deployed in this crash due to the tree impact. The air bag deployed through a tear seam in the side of the seat back. There was no evidence of damage due to deployment to the air bag. The air bag was rectangular-shaped and measured 64 centimeters (25.2 inches) in height and 26 centimeters (10.2 inches) in width. Both sides of the air bag were stitched together in three places to shape the inflation chambers. There was no evidence of occupant contact to the air bag.

The Lincoln's back center passenger (13-month-old, female) was seated in a Graco Assura rear-facing infant seat (**Figures 14**). The infant seat was manufactured by Graco Children's Products on September 26, 2005 and the model number was 44106F0F. The infant seat was constructed of a one piece plastic shell and was covered with an approximate 2 centimeters (0.8 inch) thick foam cushion. The infant seat was equipped with a five-point harness with retainer clip, carrying handle and a recline indicator. There were three sets of harness strap slots on the back of the infant seat. The harness straps were threaded through the top slots of the shell, not through the padding. The manufacturer's warning label indicated to use the infant seat only with a vehicle's two-point lap belt, lap-and-shoulder belt or the infant seat's LATCH strap. The infant seat was specified for use only for children who weigh 10 kilograms (22 pounds) or less and whose height is 73.7 centimeters (29 inches) or less.



Figure 14: Front view of Lincoln's back center infant seat

Inspection of the infant seat revealed a few stress marks on the plastic shell. There was no other evidence of crash related damage to the infant seat. The inspection also revealed that the shoulder harness straps had been routed through the same slots in the cloth pad as the upper thigh straps (**Figure 15**). In addition, the harness retainer clip was positioned just above the latch plates (**Figure 15**). The improper routing of the harness straps was also reported on the supplement to the police crash report.



Figure 15: Shoulder harness straps routed through same slots in padded cover as lap belt straps, harness retainer clip positioned just above latch plates.

The back right passenger (3-year-old, male) was seated in a Dorel Voyager belt-positioning booster seat (**Figure 16**). The child safety seat was manufactured by the Dorel Juvenile Group on January 5, 2006 and the model number was 22-211-WAL. The child safety seat was constructed of a one piece plastic shell and was covered with a approximate 1 centimeter (0.4 inch) thick foam cushion. There were two shoulder belt guides on each side of the seat back, and a lap belt path on each side of the seat at the junction of the seat cushion and seat back. The manufacturer's warning label indicated that the child safety seat was to be used only with the vehicle's lap-and-shoulder belt. The child safety seat was specified for use for children who weigh between 18.1

to 36.3 kilograms (40 and 80 pounds) and are 109 to 132 centimeters (43 to 52 inches) tall and over 1 year in age.

Inspection of the child safety seat revealed some scuffs on the top of the seat back. The plastic on the top left side of the shell also showed signs of stress. It appeared that this damage may have been due to contact with the intruding back right roof structure (**Figure 13**), which occurred during the roof impact to a tree as the vehicle rolled over. In addition, several areas of scuffing were observed at the right front corner of the seat cushion. Otherwise, the child safety seat was intact and unremarkable.

The back left passenger (6-year-old, male) was seated in a Graco TurboBooster booster seat (**Figure 17**). The booster seat was manufactured by Graco Children's Products on April 4, 2005. The model number was 8491RGB and the serial number was JJ0414050806376. The booster seat was constructed of a one-piece plastic shell with padded arm rests and a padded seat cushion. There were brackets on the back of the seat to accommodate installation of a back support. The booster seat was being used without the back support. The manufacturer's information label indicated that the booster seat should be used with the back support installed for children who were 3-10 years of age, weighed 13.6 to 45.4 kilograms (30 to 100 pounds) and were 96.5 to 144.8 centimeters (38 to 57 inches) tall. The booster seat could be used without the back support installed for children who were 4-10 years of age, weighed 18.1 to 45.4 kilograms (40 to 100 pounds) and were 101.6 to 144.8 centimeters (40 to 57 inches) tall. Inspection of the booster seat was unremarkable.



Figure 16: Front view of back right belt positioning booster seat



Figure 17: Front view of back left booster seat

Prior to the crash, the Lincoln's back center passenger [13-month-old, female; 61 centimeters and 15 kilograms (24 inches, 33 pounds)] was seated in a rear-facing infant seat. The child was seated in a reclined position.

Based on an interview with the investigating police officer and the supplement to the police crash report, the back center passenger was not restrained in the infant seat. The child had been placed in the infant seat and was not restrained by the available five-point harness. Inspection of the infant seat revealed that the harness straps were routed through the top slot in the back of the infant seat. However, when the harness straps were routed through the padded infant seat cover, they were routed through the same slots as the upper thigh belt. In addition, the harness retainer clip was positioned just above the latch plates. The infant seat had been secured in the vehicle with the lap-and-shoulder belt. The driver indicated she had buckled the belt around the seat. The belt was equipped with a light weight locking latch plate.

The vehicle's driver made no pre-crash avoidance maneuvers; therefore, the back center passenger's seated position did not change just prior to the crash. The wheel impacts with the curb probably caused the back center passenger to move up and down in her infant seat, but it is unlikely she was ejected from the infant seat during this phase of the crash. The vehicle's subsequent impact with the fire hydrant caused the back center passenger to continue forward opposite the vehicle's 12 o'clock direction of force as the Lincoln decelerated. Based on occupant kinematic principles, the unrestrained passenger was probably ejected from her infant seat at this time and she contacted the back of the front center seat back. It is not known if she continued into the front seat area at this time. As the vehicle rolled over passenger side leading, the back center passenger was displaced to the right and toward the roof. When the vehicle landed on its left roof and left roof side rail, the back center passenger probably impacted the roof. As the vehicle landed on its wheels during the fourth quarter turn, the back center passenger probably landed in the front seat area. The back center passenger was then displaced to the right and toward the roof as the vehicle rolled onto its right side and the roof impacted the tree. During this sequence, the back center passenger possibly contacted the right front passenger and probably contacted the roof. The back center passenger landed in the front right passenger floor area as the vehicle rotated clockwise off the tree and back onto its wheels. The back center passenger was found on the right front passenger floor by one of the investigating police officers.

CASE VEHICLE BACK CENTER PASSENGER INJURIES

The police crash report indicated that the back center passenger sustained a B (non-incapacitating-evident) injury and was transported by ambulance to a hospital. She was treated and released from the emergency room. The table below shows the back center passenger's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion scalp, not further specified and safety glass throughout hair	minor 190202.1,9	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
2	Contusion scalp, not further specified	minor 190402.1,9	Floor, including toe pan	Possible	Emergency room records
3	Abrasions, small, about forehead	minor 290202.1,7	Noncontact injury: flying glass, unknown source	Probable	Emergency room records

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

Prior to the crash, the Lincoln's back left passenger [6-year-old, male; 99 centimeters and 18 kilograms (39 inches, 40 pounds)] was seated in a booster seat. The child was most likely seated in a upright position in the booster seat with his back against the seat back and his feet hanging over the edge of the seat cushion.

Based on the vehicle inspection, an interview with the investigating police officer and an interview with the vehicle's driver, the back left passenger was restrained in the booster seat by the vehicle's lap-and-shoulder safety belt. The investigation indicated the shoulder belt was over the child's left shoulder. The lap belt was snug and routed across the lap belt guides under the booster seat arm rests and across the passenger's hips.

Based on SCI experience, the wheel impacts with the curb probably locked the back left passenger's safety belt retractor and caused the passenger to move up and down in his booster seat. The vehicle's subsequent impact with the fire hydrant caused the back left passenger to continue forward opposite the vehicle's 12 o'clock direction of force. As the vehicle decelerated, the passenger loaded the safety belt. As the vehicle rolled over passenger side leading, the back left passenger probably moved to the right within his restraint system and slightly toward the roof. The left side of his body possibly loaded the left rear door during the rollover. As the vehicle landed on its wheels during the fourth quarter roll, the back left passenger loaded the bottom of his booster seat and then moved right as the vehicle rolled over onto its right side. The back center passenger then moved to the right and toward the roof as the vehicle's roof impacted the tree, and he loaded his safety belt. The back left passenger remained restrained in his booster seat as the Lincoln rolled back onto its wheels and came to final rest. He was removed from the vehicle by rescue personnel.

The police crash report indicated that the back left passenger sustained a “B” (non-incapacitating-evident) injury and was transported by ambulance to a hospital. The passenger was treated and released from the emergency room. The table below shows the back left passenger’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasions, small, on forehead, not further specified	minor 290202.1,7	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
2	Lacerations {cuts}, random, on head, not further specified; no stitches required	minor 190600.1,9	Noncontact injury: flying glass, unknown source	Probable	Interviewee (driver)
3	Contusion {bruising} around stomach area, not further specified	minor 590402.1,8	Lap portion of safety belt system	Probable	Interviewee (driver)
4	Contusions, multiple, not further specified	minor 990400.1,9	Unknown contact mechanism	Unknown	Emergency room records

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

Prior to the crash, the Lincoln’s back right passenger [3-year-old, male; 76 inches and 15 kilograms (30 inches, 32 pounds)] was seated in a belt positioning booster seat. The child was seated in a upright position with his back against the booster seat back and his feet hanging over the edge of the seat cushion.

Based on the vehicle inspection, an interview with the investigating police officer and an interview with the Lincoln’s driver, the back right passenger was restrained in the booster seat by the vehicle’s lap-and-shoulder safety belt. The investigation indicated the shoulder belt was over the child’s right shoulder and the lap belt was snug and across his hips. It is not known if the shoulder belt had been routed through a shoulder belt guide located on the right side of the booster seat back.

The wheel impacts with the curb probably locked the back right passenger’s safety belt retractor and caused the passenger to move up and down in his belt positioning booster seat. The vehicle’s subsequent impact with the fire hydrant caused the passenger to continue forward opposite the vehicle’s 12 o’clock direction of force. As the vehicle decelerated, he loaded his safety belt. As the vehicle rolled over passenger side leading, the passenger probably moved to the right within his safety belt and toward the roof. This passenger remained largely in place and continued to load the safety belt system during the crash sequence. However, as the roof crushed from the tree impact, the top of the passenger’s head contacted the roof leaving a hair deposit. The intruding roof also contacted the top of the booster seat back scuffing the top of the seat back and

causing stress marks on the left side of the shell. The back right passenger remained restrained in the booster seat as the vehicle rolled back onto its wheels and came to final rest. Rescue personnel cut the back right passenger’s safety belt and removed him from the vehicle.

CASE VEHICLE BACK RIGHT PASSENGER INJURIES

The back right passenger was transported by ambulance to a hospital and was treated and released. The table below shows the back right passenger’s interview reported injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Soreness, pain neck and back, not further specified	not coded	Noncontact injury: impact forces	Probable	Interviewee (driver)
1	Contusion {bruising} left arm and shoulder, not further specified	minor 790402.1,2	Child safety seat’s right side surface	Probable	Interviewee (driver)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Prior to the crash, the Lincoln’s front right passenger [9-year-old, female; 122 inches and 25 kilograms (48 inches, 55 pounds)] was seated in an upright position with her back against the seat back and her feet on the floor. The seat was adjusted to the middle track position and the seat back was slightly reclined.

Based on the vehicle inspection and the police crash report, the front right passenger was restrained by the lap-and-shoulder safety belt.

The wheel impacts with the curb probably locked the front right passenger’s safety belt retractor and caused the passenger to move up and down in her seat. The vehicle’s subsequent impact with the fire hydrant caused the passenger to continue forward opposite the vehicle’s 12 o’clock direction of force. As the vehicle decelerated, she loaded her safety belt. This passenger remained largely in place and continued to load the safety belt system during the crash sequence. However, based on occupant kinematic



Figure 18: Lincoln’s front right passenger seat back-mounted side impact air bag, each increment on rods is 5 cm (2 in)

principles, when the vehicle impacted the tree, she loaded the deployed seat back-mounted side impact air bag (**Figure 18**). The passenger remained restrained in her seat and was removed from the Lincoln by rescue personnel.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The police crash report indicated that the front right passenger sustained a B (non-incapacitating-evident) injury and was transported by ambulance to a hospital. The front right passenger was treated and released from the emergency room. The table below shows the front right passenger’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasions, superficial, right forehead, not further specified	minor 290202.1,7	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
2	Sprain left thumb	minor 750402.1,2	Unknown contact mechanism	Unknown	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

Prior to the crash, the Lincoln’s driver [24-year-old, pregnant (23 weeks and 5 days) female; 155 centimeters and 66 kilograms (61 inches, 146 pounds)] was seated in an upright driving position with both hands on the steering wheel, her back against the seat back, her right foot on the accelerator and her left foot on the floor. The seat was adjusted to between the middle and forward most track position and the seat back was slightly reclined.

Based on the vehicle inspection and the police crash report, the front right passenger was restrained by her lap-and-shoulder safety belt.

Just prior to the crash, the Lincoln’s driver reportedly fell asleep. As a result, she may have slumped forward or to one side prior to the vehicle leaving the roadway. The driver was probably awakened by the wheel impacts with the curb and her safety belt retractor locked. Based on occupant kinematic principles, she moved forward and up and down in her seat. The subsequent impact with the fire hydrant caused the driver to continue forward opposite the vehicle’s 12 o’clock direction of force and she loaded her safety belt as the vehicle decelerated. As the vehicle rolled over passenger side leading, the driver moved to the right within her safety belt and toward the roof and continued to load her safety belt. When the vehicle landed on its left roof and left roof side rail, the driver moved toward the roof and the back right of her head impacted the intruding roof causing a nonanatomic brain injury and a laceration. As the vehicle landed on its wheels during the fourth quarter roll, the driver loaded the bottom of her seat and then moved right within her safety belt as the vehicle rolled over onto its right side. The driver moved to the right, toward the roof and loaded her safety belt when the roof impacted the tree. She moved back

to the left and loaded her seat cushion as the vehicle rolled back onto its wheels and came to final rest. The driver remained restrained in her seat and rescue personnel cut her safety belt and removed her from the Lincoln.

CASE VEHICLE DRIVER INJURIES

The police crash report indicated that the driver sustained a B (non-incapacitating-evident) injury and was transported by ambulance to a hospital. The driver was admitted to the hospital and kept overnight for observation due to her pregnancy. The table below shows the Lincoln driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with loss of consciousness of unknown duration, confusion, amnesia for event, GCS=14	moderate 160606.2,0	Roof	Probable	Emergency room records
2	Lacerations x 2 {cuts} on forehead; one, 7.6-10.2 cm (3-4 in) vertically on left forehead, second, 2.5 cm (1 in) vertically over right eye ¹	minor 290602.1,7	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
3	Laceration {cut} behind right ear ² , not further specified	minor 190600.1,1	Roof	Certain	Interviewee (same person)
4	Abrasions, multiple, superficial, to forehead with low grade oozing blood loss and anemia ³	minor 290202.1,7	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
5	Abrasion on {left} neck, not further specified	minor 390202.1,2	Torso portion of safety belt system	Possible	EMS treatment record
6	Abrasion on chest, not further specified	minor 490202.1,4	Torso portion of safety belt system	Possible	EMS treatment record

¹ Extensive lesion detail provided by interviewee.

² According to this patient's CT Head scan, there was a questionable 3.0 millimeter foreign body lateral to the right mastoid and posterior to the right ear. Furthermore, there was air in the soft tissues at this location that may have been due to laceration.

³ This patient's hemoglobin was 8.5, which is anemic, but it is unclear whether her anemia is due to her pregnancy or related to blood loss.

