

On-Site Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS10020
2005 Toyota Tundra
Colorado
September 2010

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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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**Dynamic Science, Inc.
Crash Investigation
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TABLE OF CONTENTS

Background. 1

Summary. 1

 Crash Site. 1

 Pre-Crash. 2

 Crash. 2

 Post-Crash. 3

2005 Toyota Tundra. 3

 Description. 3

 Exterior Damage. 4

 Event Data Recorder. 5

 Interior Damage. 8

Manual Restraint System. 8

Supplemental Restraint System. 9

Rollover. 11

2005 Toyota Tundra Occupants. 11

Scene Diagram. 17

BACKGROUND

This on-site investigation focused on the rollover dynamics of a 2005 Toyota Tundra (**Figure 1**) involved in a single-vehicle crash and the injuries sustained by the four adult male occupants. The Toyota was being driven northbound on a state highway by a restrained 19-year-old male driver when it departed the roadway and overturned. The three other occupants in the vehicle included an 18-year-old male seated in the front right seat, a 19-year-old male seated in the rear left seat, and a 19-year-old male seated in the rear right seat. The Toyota was equipped with Certified Advanced 208-Compliant (CAC) frontal air bags, seat-mounted side impact air bags, and combination side impact/rollover-sensing inflatable curtain (IC) air bags. During the crash the Toyota's frontal air bags and IC air bags deployed, and the rear right-seated occupant was completely ejected through the right rear door which came open. All the occupants were transported to local hospitals where they were treated for injuries ranging from minor to serious. The ejected occupant sustained multiple serious injuries and was declared deceased two hours post-crash.



Figure 1. Subject vehicle, 2005 Toyota Tundra

This crash was identified by a state police officer who sent an email notification including a copy of the police report to Dynamic Science, Inc. (DSI) on September 21, 2010. DSI forwarded the police report to the National Highway Traffic Safety Administration (NHTSA) for review and DSI was then instructed to obtain permission to image the vehicle's Event Data Recorder (EDR) which was supported by the Toyota Readout Tool (ROT). On September 27, 2010, DSI was notified by the attorney representing the Toyota's owner that permission to image the EDR was granted and the case was assigned later that day. The Toyota was located at a police tow facility and the vehicle inspection was completed on September 30, 2010 with state police officers present during the inspection. The EDR data was imaged and displayed using software version 1.4.1.1 and a summary of the data is incorporated into this report.

CRASH SUMMARY

Crash Site

The crash occurred on a three-lane north/south state highway (**Figure 2**) at 0510 hours in September 2010. At the time of the crash the weather was clear and the roadway was dry. The temperature at the nearest reporting station was 10.8° C (51.5° F) and winds were calm. The roadway consisted of two northbound lanes and one southbound lane separated by a double solid/dashed yellow painted stripe. The two northbound lanes measured 3.5 m (11.5 ft) and 3.7



Figure 2. Crash site showing northbound approach of subject vehicle

m (12.1 ft) in width and the southbound lane measured 3.6 m (11.9 ft) in width. The roadway edges were marked by solid white painted fog lines and paved shoulders measuring 2.0 m (6.0 ft) in width. The roadway was straight in the northbound direction and had an uphill slope ranging from positive 3.6 percent at 150 m (500 ft) prior to impact to positive 2.0 percent at the point of roadway departure. The posted speed limit was 104 km/h (65 mph) and the asphalt roadway and shoulders were in good condition. Outboard of the west shoulder was an outcropping of rock at the base of an ascending embankment. To the north of the embankment and to the left of the roadway were a cable rail barrier, two trees, and a descending embankment.

Pre-Crash

The Toyota was traveling northbound in the outboard lane and the driver fell asleep¹. The vehicle crossed over the inboard northbound lane and the southbound lane and departed the roadway on the left edge.

Crash

The crash sequence consisted of five events including the rollover and impacts with four off-road objects. After the Toyota departed the roadway on the left edge, its front left corner impacted a rock embankment. The vehicle sustained direct contact to the front end and left side including the left front and rear tires (Event 1). After the first impact, the vehicle initiated a counterclockwise yaw and its right rear tire deposited a scuff mark on the paved shoulder measuring 34.5 m (113.2 ft) in length. The vehicle's right front tire deposited a tire track measuring 22.5 m (73.8 ft) in length in the unpaved ground. Both right side tires then engaged the ground inducing a right side leading trip rollover (Event 2) and the right front tire deposited a furrow in the ground measuring 6.3 m (20.7 ft) in length.



Figure 3. Crash site showing locations of tire furrow (left), tree impact (center) and cable rail barrier impact (right)

During the first quarter-turn, the vehicle's right side impacted a tree (Event 3) and a cable rail barrier (Event 4) (**Figure 3**). The tree measured 23.0 cm (9.0 in) in diameter and it was fractured at 2.3 m (7.5 ft) above grade. Additionally, the impact uprooted the tree trunk. Damage to the cable rail barrier was not documented because it had been repaired prior to the scene inspection. The vehicle continued rolling for an additional 21.7 m (71.2 ft) and impacted a second tree measuring 18.0 cm (7.0 in) in diameter (Event 5). The vehicle continued to overturn as it traveled down a descending embankment. It came to rest on its wheels and facing south at the base of the embankment. From the trip point to final rest the vehicle rolled a total of twelve quarter-turns and traveled 47.0 m (154.0 ft). During the fifth quarter-turn, the rear right-seated occupant was ejected from the vehicle through the right side rear door, which came open during the crash. The occupant came to rest on the ground

¹ Based on the police report and the interview with the vehicle's owner

approximately 18.0 m (60.0 ft) southeast of the vehicle's point of rest.

For Event 1 the Barrier algorithm of the WinSMASH program calculated a Total Delta-V of 11.0 km/h (6.8 mph); the longitudinal and lateral components were -11.0 km/h (-6.8 mph) and 0.0 km/h. The program calculated a Barrier Equivalent Speed (BES) of 11.3 km/h (7.0 mph). Based on the coding protocols for corner impacts, the WinSMASH results were considered borderline. The subsequent impacts were non-horizontal and were out of scope of the WinSMASH program.

Post-Crash

Following the crash, the driver unbuckled his safety belt and exited the vehicle unassisted through the front left window opening. The rear left occupant unbuckled his safety belt and exited the vehicle through the left rear door, which was operational. The rear left occupant then assisted the front right occupant from the vehicle, probably through a second row door. The rear right seated occupant was found by the other occupants approximately 18.0 m (60.0 ft) southeast of the vehicle, near the area of the second tree impact (Event 5).

Approximately 15 minutes post-crash, a passing motorist stopped at the crash site and called for emergency assistance. Approximately 45 minutes after the crash, ground and helicopter ambulances arrived on-scene. The driver and the rear left occupant were ground transported to a local hospital where they arrived at approximately 0725 hours. The driver of the Toyota arrived at the hospital emergency department where he was treated for approximately three hours and then released. The driver missed one-to-two weeks of school due to his injuries.

The rear left occupant arrived at the hospital with a reported GCS of 15. He was treated for approximately four hours and released later that day. His follow-up treatment consisted of physical therapy that continued for approximately four months. The occupant missed one week of school due to his injuries.

The front right and rear right occupants were air transported by helicopter to a local hospital. The front right occupant arrived at the hospital with a reported Glasgow Coma Score (GCS) of 15. He was admitted at 0922 hours and was released following two days of treatment. He sought follow-up treatment including physical therapy and missed approximately four weeks of school due to his injuries.

The rear right occupant was treated in the hospital for a short time before being declared deceased at 0710 hours. The vehicle was towed due to damage and was impounded by police for evidentiary reasons.

2005 TOYOTA TUNDRA

Description

The 2005 Toyota Tundra was a four-door light pickup truck. It was identified by the Vehicle Identification Number (VIN): 5TBDT44105Sxxxxxx and its date of manufacture was October 2004. The exact odometer reading was unknown due to the inoperable electronic odometer, but based on the interview it was approximately 145,000 km (90,000 mi). The vehicle was equipped with a 4.7-liter, 8-cylinder engine, automatic transmission, 4-wheel drive, and power steering with tilt column functionality. Additional standard features included tinted rear windows, 4-wheel anti-lock brakes

(ABS) with Electronic Brake Distribution (EBD), and a tire pressure monitoring system.

The vehicle manufacturer recommended P265/65R17 tires for the front and rear with a cold tire pressure of 200 kPa (29 psi) for the front and 221 kPa (32 psi) for the rear. The Toyota was equipped with Big O A/T Big Foot tires of the recommended size on the front and rear and they were mounted on original equipment manufacturer (OEM) ten-spoke aluminum rims. The specific tire data at the time of the vehicle inspection² was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	7 mm (9/32 in)	No	Tire cut, punctured and de-beaded
LR	Tire flat	5 mm (6/32 in)	No	Tire de-beaded
RR	Tire flat	5 mm (6/32 in)	No	Tire de-beaded
RF	Tire flat	6 mm (8/32 in)	No	Tire de-beaded

The Toyota's interior was equipped with fabric-covered five-passenger seating. The front row outboard bucket seats were separated by a center console and equipped with height-adjustable head restraints. The back row seat was a 60/40 split bench with folding backs and height-adjustable head restraints.

Exterior Damage

The Toyota sustained direct and induced damage to the front end and left side during the impact with the rock embankment (Event 1). The left front tire was cut, flattened and de-beaded, and the rim was fractured in two locations. The left rear tire was flattened and de-beaded and the rim was fractured with a 17.0 x 4.0 cm (6.7 x 1.6 in) section of the outboard flange missing. The left rear tire had snagged on the embankment lengthening the left side wheelbase by 15.0 cm (5.9 in). The direct damage to the front end began at the front left bumper corner and extended 15.0 cm (5.9 in) to the right. The Field L was distributed from bumper corner to bumper corner and measured 150.0 cm. Damage to the left side began at the front left bumper corner, extended 490.0 cm (192.9 in) down the left side, and ended 49.0 cm (19.3 in) aft of the left rear axle. Six crush measurements were taken at bumper level as follows: $C_1 = 7.0$ cm (2.8 in), $C_2 = 2.0$ cm (0.8 in), $C_3 = 2.0$ cm (0.8 in), $C_4 = 1.0$ cm (0.4 in), $C_5 = 0$ cm, $C_6 = 0$ cm. Maximum crush was located at C1. The Collision Deformation Classification (CDC) for Event 1 was 12FLEE9.

The Toyota sustained direct damage to the left, right, and top planes during the rollover (Event 2). In addition to sheet metal damage, the right front wheel was displaced from the axle. Direct damage to the roof was distributed vertically from roof side rail to roof side rail and measured 120.0 cm (47.2 in). Direct damage to the top plane was distributed longitudinally beginning at the hood and ending at the tailgate. Maximum lateral crush to the greenhouse was located on the right roof side rail aft of the B-pillar at 162.0 cm (63.8 in) forward of the rear axle and measured 13.0 cm (5.1 in).

² Vehicle inspection was completed 21 days after the crash date.

Maximum vertical crush to the greenhouse was located on the right windshield header at 10.0 cm (3.9 in) inboard of the right roof side rail and measured 42.0 cm (16.5 in) (**Figure 4**). The CDC for Event 2 was 00TDDO4.



Figure 4. Maximum vertical crush to greenhouse documentation

The first tree impact (Event 3) occurred during the first quarter-turn of the rollover and was a non-horizontal impact. The direct damage measured 24.0 cm (9.5 in) in width beginning on the front right door panel and ending at the roof side rail. The crush damage from the tree impact was minor and was overlapped by subsequent rollover damage. The CDC for Event 3 was 00RPHN2.

The impact to the cable rail barrier (Event 4) also occurred during the first quarter-turn of the rollover and was a non-horizontal type impact. The direct damage was located on the right side rear aspect of the cargo bed and measured 35.0 cm (13.8 in) in width. The crush damage from the cable barrier guardrail was minor and was overlapped by subsequent rollover damage. The CDC for Event 4 was 00RBME2.

During the fifth quarter-turn of the rollover the Toyota's top plane impacted a second tree measuring 17.8 cm (7.0 in) in diameter that was fractured and uprooted (Event 5). The direct damage was located on the right roof and measured 20.0 cm (7.9 in) in width. The damage was minor and was overlapped by subsequent rollover damage. The CDC for Event 5 was 00TPZN2.

Event Data Recorder

The Toyota's EDR was imaged by the DSI investigator by connecting the ROT directly to the EDR module Number 89170-0C210. The EDR was configured to capture up to three frontal events and one rollover event. It was not configured to capture side impact events or pre-crash data. The EDR report was summarized as follows:

Data Table	
R/O ³ Deployment Time	1345.0 milliseconds (ms)
R/O RA MAX Value within 2 sec. from trigger	106.5
R/O CSA-Manual Cut OFF ⁴	Deployment Mode
R/O Writing Flag	Finished Writing

³ Assumed to mean Rollover

⁴ Assumed to refer to the manual suppression switch for the roll-senor that triggers the deployment of the IC air bags

New Page	0 Page
Freeze Signal	Freeze
Deployment Time	0 ms
Deployment Stage Driver	Not Fired
Deployment Stage Passenger	Not Fired

Graph Data	
Latest/Frozen	Bank 0
Freeze Signal	Freeze
Record Status	Recorded
Individual Data	
Time From Previous Event	5000 ms
Time From Last Pre-Crash Data (N/A)	(N/A)
Pre-Crash Data Flag (N/A)	(N/A)
Shift Position (N/A)	(N/A)
Seat Position Driver	RW ⁵
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	Belted
Occupant Detection Passenger	AM50 ⁶
PAB-Manual Cut OFF (N/A)	(N/A)
Ignition Cycles	0 times
Lamp On Term	0 minutes
Event Counter	1
Writing Flag	Finished Writing

⁵ Assumed to mean Rearward

⁶ Assumed to mean Adult Male 50th Percentile Weight Detection

Post-Crash Data ⁷					
ms	Vel Chg ⁸	ms	Vel Chg	ms	Vel Chg
10.0	0.4	60.0	0.7	110.0	1.0
20.0	1.1	70.0	0.4	120.0	1.3
30.0	0.9	80.0	0.3	130.0	1.3
40.0	0.6	90.0	0.4	140.0	1.5
50.0	0.6	100.0	0.9	150.0	1.7 ⁹

The next most recent / BANK1 page contained no Individual, Pre-Crash or Post-Crash Data. The past maximum Delta-V / BANK2 page contained no Individual, Pre-Crash, or Post-Crash Data.

R/O Roll Angle and Lateral G		
Count	R/O Roll Angle	R/O Lateral G
0.0	-3.3	-11.5
1.0	-3.3	-11.5
2.0	-3.3	-7.7
3.0	-3.3	-7.7
4.0	-3.3	0.0
5.0	-2.5	3.8
6.0	-2.5	3.8
7.0	-2.5	3.8
8.0	-1.7	3.8
9.0	-1.7	7.7
10.0	-1.7	3.8
11.0	-0.8	0.0
12.0	-0.8	-3.8

⁷ Associated with frontal air bag deployment event

⁸ Means Velocity Change

⁹ Maximum recorded post-crash DeltaV

13.0	-0.8	-11.5
14.0	-0.8	-11.5
15.0	-0.8	-3.8
16.0	-0.8	0.0
17.0	-0.8	0.0
18.0	-0.8	-3.8
19.0	-0.8	-3.8

Interior Damage

The Toyota sustained severe interior damage resulting from impact forces, intrusion, occupant loading, and occupant contacts. The windshield was fractured and out of place and the side glass and backlight were disintegrated. The occupant compartment was reduced in size by vertical intrusion of the windshield header, roof, and instrument panel (IP); by lateral intrusion of the left and right A-pillars, right B-pillar and roof side rail, and front right door panel; and by longitudinal intrusion of the IP. The front row safety belt components and driver air bag showed scuff marks from occupant loading, the front passenger air bag was torn by fractured glazing, and the left IC air bag was torn from ground contact. The left and right front door panels were deformed outboard by occupant contact, the left rear door panel showed scuff marks from occupant contact, and the right rear door panel showed discoloration from occupant contact. The roof showed blood deposits, scuff marks and tears from occupant contacts. Additionally, the right rear door panel came open during the crash and was the ejection medium for the rear right-seated occupant.

Manual Restraint System

The vehicle's front row seating was equipped with 3-point manual lap and shoulder safety belts with continuous loop webbing, sliding latch plates, adjustable D-ring anchorages, and retractor pretensioners. The driver's safety belt was equipped with an Emergency Locking Retractor (ELR) and the front right passenger's safety belt had a switchable ELR/Automatic Locking Retractor (ALR). The second row was equipped with continuous loop 3-point manual safety belts for the three seating positions. The outboard position safety belts were configured with adjustable D-ring anchorages and the center position safety belt was integrated into the seat back. The safety belts were equipped with switchable ELR/ALR retractors.

The driver's safety belt D-ring anchorage was set to the full-up position and the latch plate was scratched indicating historical usage. The safety belt retractor pretensioner had actuated during the crash locking the webbing in the spooled-out position. The safety belt webbing revealed stretch marks within an 8.0 cm (3.1 in) segment beginning 100.0 cm (39.4 in) above the stop button where it contacted the D-ring and the D-ring had scuff marks as well. The evidence indicated that the safety belt was used.

The front right occupant's adjustable D-ring was set to the full-down position and the latch plate was scratched indicating historical usage. The safety belt retractor pretensioner had actuated during the crash locking the webbing in the spooled-out position. The webbing revealed scuff marks within

a 6.0 cm (2.4 in) segment beginning 106.0 cm (41.7 in) above the stop button and the D-ring showed occupant loading marks (**Figure 5**). Based on the vehicle inspection the front right safety belt was used by this occupant.

The second row left safety belt was found in the stowed position, the adjustable D-ring was in the full-up positions, and the latch plate was scratched indicating historical usage. The police report stated that this occupant was ejected during the rollover. However, based on the interview, the occupant's kinematics, and the occupant's injuries, it was determined that the lap and shoulder safety belt was used to restrain the occupant during the crash¹⁰ and the occupant was not ejected.



Figure 5. Front right occupant's safety belt webbing and D-ring showing evidence of loading

The second row right safety belt was found in the stowed position, the adjustable D-ring was in the full-up position, and the latch plate was scratched indicating historical usage. The occupant was completely ejected during the rollover and based on the interview and the vehicle inspection the safety belt was not used by the occupant at the time of the crash.

Supplemental Restraint System

The vehicle's Supplemental Restraint System (SRS) included an air bag control module (ACM), driver and passenger dual stage frontal air bags, seat-mounted side impact air bags, and combination side impact/rollover-sensing IC air bags. The vehicle manufacturer has certified that the frontal air bags are compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system also included seat track positioning sensors and a front right occupant weight-recognition sensor with an automatic air bag switch. The two frontal air bags deployed during the frontal impact (Event 1). The driver's frontal air bag was a replacement air bag that was installed after another deployment event occurred in 2005. The passenger's frontal air bag and the side air bags were original to the vehicle and had not been previously serviced or recalled.

The left frontal air bag deployed from the steering wheel hub through an H-configured flap. The air bag was circular in shape and measured 60.0 cm (23.6 in) in diameter in its post-inflated state. It was configured with two internal tethers and two vent ports. The air bag showed a 2.0 cm (0.8 in) scuff mark in the upper right quadrant of the front panel indicating occupant loading. The scuff mark was located 22.0 cm (8.7 in) from the perimeter seam and was deposited by the driver.

The right frontal air bag deployed from the top IP through an H-configured cover flap. The upper cover flap measured 5.0 x 20.0 cm (2.0 x 7.9 in) and showed scuff marks from contact with the fractured windshield. The air bag was rectangular in shape and measured 45.0 cm (17.7 in) in width, 58.0 cm (22.8 in) in height, and 40.0 cm (15.7 in) in excursion in its post-inflated state. It was configured with two vent ports and no tethers. The top panel just aft of the top cover flap was torn

¹⁰ The occupant had safety belt related injuries to the left shoulder.

and abraded by contact with the fractured windshield and the damaged area measured 6.0 x 14.0 cm (2.4 x 5.5 in). The front panel of the air bag showed abrasions from contact with the cover flaps.

The Toyota was equipped with combination side impact/rollover-sensing IC air bags for the front and rear outboard seat positions. The left and right IC air bags deployed during the first quarter-turn of the rollover and were triggered by the vehicle's roll angle. The vehicle was equipped with an IC air bag cut-off switch used to suppress the roll-sensor during off-road driving activities. Based on the EDR report, the switch status was set to "Off".

The left IC air bag deployed from the left roof side rail above the first (Figure 6) and second rows. The IC air bag measured 180.0 cm (70.9 in) in length and 52.0 cm (20.5 in) in overall height. At the A-pillar, B-pillar, and C-pillar, the bottom edge of the air bag curved upward where measured 40.0 cm (15.7 in) in length. The front row sector of the IC air bag completely covered the side glass and it extended 5.0 cm (2.0 in) below the bottom edge of the side glass.

The second row sector of the IC air bag covered the side glass except for a 3.0 x 8.0 cm (1.2 x 3.1 in) section in the rear lower corner at the C-pillar. The air bag was configured with two tethers at the rearward aspect. The upper tether was located at the roof side rail and the lower tether was located 15.0 cm (5.9 in) above the bottom of the window frame. The tethers were spaced 26.0 cm (10.2 in) apart in their post-inflated state and were fixed in place. The lower tether prevented the left side IC air bag from providing full coverage of the side glass and upper door panel (Figure 7). The air bag had holes and abrasions measuring 10.0 x 15.0 cm (3.9 x 5.9 in) located in the outboard panel that were caused by ground contact during the rollover.

The right IC air bag deployed from the right roof side rail above the front and second rows. A blood transfer on the air bag was probably deposited by the front right occupant. In its post-inflated state, the two rearward tethers of the right IC air bag were positioned close together at the roof side rail (Figure 8) preventing the air bag's rearward sector from extending vertically to the bottom of the



Figure 6. Left IC air bag second row sector

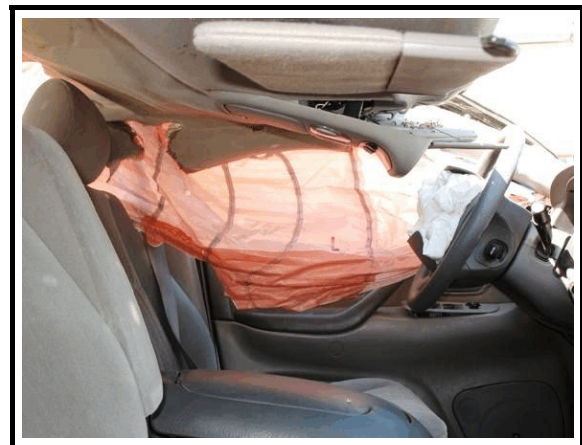


Figure 7. Left IC air bag first row sector



Figure 8. Right IC air bag second row sector

side glass. The air bag's lower sector overlapped the upper sector yielding a length of coverage measuring 32.0 cm (12.6 in) versus 40.0 cm (15.7 in) for the left IC air bag. This configuration revealed an uncovered section of the window opening measuring approximately 20.0 cm (7.9 in) in height and 60.0 cm (23.6 in) length. Additionally, the lower tether had a 5.0 cm (2.0 in) tear where it was connected to the air bag. Efforts to move the tether lower down on the C-pillar and extend the air bag vertically were unsuccessful. Since the right rear door opened during the rollover, the right IC air bag's lack of medium coverage did not contribute to the ejection of the occupant.

Rollover

The 2005 Toyota Tundra's Static Stability Factor (SSF) rating was unknown and the vehicle's rollover resistance was not rated. The SSF of a vehicle is an at-rest calculation of its rollover resistance based on its track width and center of gravity. The vehicle's ABS incorporated sensors to prevent the wheels from locking under hard braking and Electronic Stability Control (ESC) distributed braking force between the front and rear wheels according to driving conditions. The Toyota's tires were in good condition and had tread depth ranging from 5 - 7 mm (6 - 9/32 in). At the time of the vehicle inspection the tires were deflated due to damage and their pre-impact inflation levels were unknown. The road surface was dry and in good condition and was non-contributory to the rollover.

After the Event 1 embankment impact the Toyota initiated a counterclockwise yaw and its right front tire departed the paved shoulder and traveled onto unpaved ground. The right front tire furrowed into the ground and the right rear tire and rim engaged the paved shoulder. The opposing lateral forces against the tires induced a right side leading trip rollover. During the first quarter-turn the vehicle's right side impacted a tree and a cable rail barrier. The vehicle continued to overturn and during the fifth quarter-turn the rear right occupant was completely ejected. The vehicle traveled down a descending embankment as it continued to overturn. The slope of the embankment was approximately 45 percent and the estimated elevation loss was 9.0 m (30.0 ft). The Toyota came to rest on its wheels facing south at the base of the embankment. The vehicle rolled a total of 12 quarter-turns and the roll distance was 47.0 m (154.0 ft).

2005 TOYOTA TUNDRA OCCUPANTS

Driver Demographics

Age/Sex:	19 years/Male
Height:	175 cm (69 in)
Weight:	82 kg (181 lb)
Eyewear:	None
Seat Type:	Bucket with adjustable head restraint
Seat Track Position:	Between middle and full-rear track
Manual Restraint Usage:	Lap and shoulder belt used
Usage Source:	Vehicle inspection
Air Bags:	Frontal air bag and IC air bag deployed, seat-mounted side air bag not deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited through left side window opening unassisted
Transport from Scene:	Ground ambulance
Medical Treatment:	Treated and released

Driver Injuries

Inj . No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Laceration, minor, 3.0 cm (1.2 in), right neck	310602.1,1	Windshield	Possible
2	Fractures, right nasal bone	251000.1,4	Frontal air bag	Possible
3	Abrasions, right scalp	110202.1,1	Roof	Possible

Source: Driver's medical records

Driver Kinematics

The 19-year-old male driver was seated in a normal posture and was restrained by the vehicle's lap and shoulder belt. The driver's seat was adjusted between the mid-to-rear track position and the seat back was reclined slightly. The Toyota was traveling at an unknown speed and the driver had reportedly fallen asleep prior to impact. The frontal impact with the rock embankment triggered the deployment of the vehicle's frontal air bags and actuation of the driver's safety belt pretensioner. The driver loaded the safety belt with his chest and deposited scuff marks on the webbing and D-ring. His face possibly loaded the air bag and he sustained fractures to his nasal bones. His right forearm loaded the air bag and deposited a scuff in the upper left quadrant near the seam. The vehicle then initiated a counterclockwise yaw followed by a right side leading trip rollover that triggered the deployment of the left IC air bag. The driver was displaced to the right in response to the roll direction and was held in place in his seat by the tensioned safety belt. During the rollover the driver's left flank contacted the left door panel deforming it outboard 3.0 cm (1.2 in). The roof intruded vertically deforming the drivers head restraint and contacting the driver's head. He sustained scalp abrasions and deposited a blood deposit and a tear on the roof. His right neck possibly contacted the fractured windshield and sustained a minor laceration. The driver remained in place in his seat until the vehicle came to rest.

Front Right Occupant Demographics

Age/Sex: 18 years/Male
 Height: 175 cm (69 in)
 Weight: 79 kg (175 lb)
 Eyewear: None
 Seat Type: Bucket with adjustable head restraint
 Seat Track Position: Between middle and full-rear track
 Manual Restraint Usage: Lap and shoulder belt used
 Usage Source: Vehicle inspection
 Air Bags: Frontal air bag and IC air bag deployed, seat-mounted side air bag not deployed
 Egress from Vehicle: Exited through right side door with assistance
 Transport from Scene: Ground ambulance
 Medical Treatment: Hospitalized two days

Front Right Occupant Injuries

Inj . No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1 2	Elbow fracture, right proximal segment, ulna; and anterior dislocation of the radial head	752113.2,1 772032.1,1	Right door panel, rear upper quadrant	Probable
3 4	Multiple abrasions, forehead and face	210202.1,7 210202.1,4	Roof	Possible
5	Abrasion, right neck	310202.1,1	Safety belt webbing	Certain
6 7	Abrasions and contusions, right elbow	710202.1,1 710402.1,1	Right door panel, rear upper quadrant	Probable
8	Abrasion, right knee	810202.1,1	Lower right IP	Probable
9	Abrasions, left shoulder	710202.1,2	Other occupant	Possible

Source: Occupant's medical records

Front Right Occupant Kinematics

The 18-year-old male front right occupant was seated in a normal posture and was restrained by the vehicle's lap and shoulder safety belt. Based on the occupant's medical records, he was asleep prior to the crash and was awaked during the rollover. At impact with the embankment the occupant's frontal air bag deployed and his safety belt pretensioner actuated. He was displaced forward and loaded the safety belt with his chest depositing scuff marks to the webbing and D-ring causing an abrasion to his right neck. During the first quarter-turn the occupant was displaced to the right and the right IC air bag deployed. His right elbow contacted the right door panel in the rear upper quadrant resulting in a fracture of the ulna, a dislocation of the radius, and abrasions and contusions. The occupant's right flank contacted the same area and deformed the door panel 7.0 cm (2.8 in) outboard. Additionally, his right hip contacted the rear lower quadrant and deposited scuff marks to the door panel. When the vehicle's roof contacted the ground it and the windshield intruded vertically into the occupant compartment. The occupant contacted the roof, sun visor and windshield with his face and head. He sustained multiple abrasions to his forehead and face, and left blood deposits on the sun visor and roof. At some time during the rollover, the occupants' left shoulder was possibly contacted by the feet or legs of the unrestrained occupant seated in the rear right seat. The other occupant reportedly had his feet between the front row seats prior to the crash and the front right occupant sustained abrasions to his left shoulder. Following the crash, he was transported to a local hospital where he was admitted for two days and then was released.

Second Row Left Occupant Demographics

Age/Sex: 19 years/Male
 Height: 180 cm (71 in)
 Weight: 107 kg (236 lb)
 Eyewear: None
 Seat Type: Split bench with folding backs and adjustable head restraint
 Seat Track Position: N/A

Manual Restraint Usage: Lap and shoulder belt used
 Usage Source: Vehicle inspection
 Air Bags: IC air bag deployed
 Egress from Vehicle: Exited through left side door unassisted
 Transport from Scene: Ground ambulance
 Medical Treatment: Treated and released

Second Row Left Occupant Injuries

Inj . No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1 2	Abrasions and contusions, left shoulder	710202.1,2 710402.1,2	Safety belt webbing	Certain
3	Strain, cervical spine	640278.1,6	Impact forces	Probable

Source: Occupant's medical records

Second Row Left Occupant Kinematics

The 19-year-old male occupant was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt. During the frontal impact the occupant was displaced forward in response to the direction of force and he loaded the vehicle's shoulder belt. He sustained abrasions and contusions to the left shoulder and was held in place in his seat by the safety belt. During the first quarter-turn of the rollover the occupant was displaced to the right and during subsequent quarter-turns he was displaced toward the roof, to the left and to the right. His left foot deposited scuff marks to the forward upper quadrant of the left door panel. The occupant sustained a strain of the cervical spine due to impact forces. He remained in his seated position until the vehicle came to final rest.

Second Row Right Occupant Demographics

Age/Sex: 19 years/Male
 Height: 180 cm (71 in)
 Weight: 97 kg (214 lb)
 Eyewear: None
 Seat Type: Split bench with folding backs and adjustable head restraint
 Seat Track Position: N/A
 Manual Restraint Usage: Lap and shoulder belt not used
 Usage Source: Vehicle inspection
 Air Bags: IC air bag deployed
 Egress from Vehicle: Completely ejected through right side door
 Transport from Scene: Ground ambulance
 Medical Treatment: Declared deceased in Emergency Room

Second Row Right Occupant Injuries

Inj. No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Abrasions, right cheek and chin	210202.1,1	Ground	Probable
2 3	Contusion and laceration NFS, right ear	210402.1,1 210600.1,1	Ground	Probable
4	Abrasions, right neck	310202.1,1	Ground	Probable
5 6	Laceration NFS and contusion, posterior scalp	110600.1,6 110402.1,6	Ground	Probable
7	Abrasions, right chest	410202.1,1	Ground	Probable
8	Abrasions, right abdomen	510202.1,1	Ground	Probable
9 10	Abrasions and lacerations NFS, right back	410202.1,6 410600.1,6	Ground	Probable
11	Fractures, right ribs R5-R8	450203.3,1	Right door panel, rear upper quadrant	Possible
12	Hemothorax NFS, bilateral	442200.3,3	Right door panel, rear upper quadrant	Possible
13	Lacerations NFS, right lung	441430.3,1	Right door panel, rear upper quadrant	Possible
14	Lacerations NFS, liver	541820.2,1	Right door panel, rear upper quadrant	Possible
15 16	Abrasions and lacerations NFS, right arm	710202.1,1 710602.1,1	Ground	Probable
17	Lacerations, minor, left upper arm	710602.1,2	Ground	Probable
18 19	Abrasions and lacerations NFS, right leg	810202.1,1 810600.1,1	Ground	Probable
20	Abrasions, left knee	810202.1,2	Ground	Probable
	Exsanguination (blood loss, amount unknown)	Not codable	N/A	N/A
	Hemoperitoneum (presence of blood in the peritoneal cavity, amount unknown)	Not codable	N/A	N/A

Source: Occupant's autopsy report

Second Row Right Occupant Kinematics

The 19-year-old male occupant was unrestrained in a semi-reclining position with his legs and feet positioned forward between the front row outboard seats. During the first impact the occupant was displaced forward in response to the direction of force and remained in the second row of the occupant compartment. During the first quarter-turn of the rollover the IC air bags deployed and this occupant was displaced from his seated position to the right. His right chest and flank loaded the right door panel and he sustained fractures to the right ribs, bilateral hemothoraces, and lacerations to his right lung and liver. During the rollover he continued to be displaced from his seat within the second row area. During the fifth quarter-turn the occupant contacted the right door panel and the door opened due to deformation. The occupant was displaced from the vehicle, contacted the ground, and sustained abrasions, contusions and minor lacerations to his face, thorax, and extremities. Following the crash, the occupant was air transported to a local hospital where he was pronounced deceased two hours post-crash.

Scene Diagram

