On-Site Side Air Bag Investigation
Dynamic Science, Inc. (DSI), Case Number DS10018
2008 Toyota Scion xB
Nevada
July 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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16. Abstract

The focus of this on-site investigation was the deployed side air bags and the injuries sustained by the driver of a 2008 Toyota Scion xB involved in a side impact crash. The Toyota was equipped with Certified Advanced 208-Compliant (CAC) frontal air bags, seat-mounted side impact air bags, and side impact inflatable curtain (IC) air bags. The vehicle was being driven by a restrained 42-year-old male who was traveling northbound through a four-leg intersection. The other vehicle was a 2008 Nissan Frontier that was being driven eastbound through the intersection by a 20-year-old male. The Toyota crossed the path of the Nissan and the front end of the Nissan impacted the left side of the Toyota. At impact, the Toyota's left seat-mounted side impact air bag and left IC air bag deployed. The driver of the Toyota sustained minor injuries and was transported to a local hospital. Both vehicles came to rest in the intersection and were towed due to damage.

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Background

The focus of this on-site investigation was the deployed side air bags and the injuries sustained by the driver of a 2008 Toyota Scion xB (**Figure 1**) involved in a side impact crash. The Toyota was equipped with Certified Advanced 208-Compliant (CAC) frontal air bags, seat-mounted side impact air bags, and side impact inflatable curtain (IC) air bags. It was being driven by a restrained 42-year-old male who was traveling northbound through a four-leg intersection. The other vehicle was a 2008 Nissan Frontier that was being driven eastbound through the intersection by a 20-year-old male. The Toyota crossed the path of the Nissan and the front end of the Nissan impacted the left side of the Toyota. At impact, the Toyota's left seat-mounted side impact air bag and left IC air bag deployed. The driver of the Toyota sustained minor injuries and was transported to a local hospital. Both vehicles came to rest in the intersection and were towed due to damage. The vehicles were declared total losses by their respective insurance companies.

Figure 1. Subject vehicle, 2008 Toyota Scion xB

This investigation was identified by a Dynamic Science, Inc. (DSI) investigator from a review of an auto auction internet website. Photographs of the subject vehicle were obtained from the auction website and a copy of the police report was obtained from the investigating police agency. On August 26, 2010, DSI forwarded images and a copy of the police report to the National Highway Traffic Safety Administration (NHTSA) for review and the case was assigned. Permission to inspect the vehicle was obtained from the insurance company and the inspection was completed at the auction facility on August 31, 2010. The vehicle's Event Data Recorder (EDR) was supported by the Toyota Readout Tool (ROT) and the EDR data was imaged using software version 1.4.1.0. The EDR data was displayed using ROT software version 1.4.1.1 and a summary of the data was incorporated into this report.

The Nissan was sold to a private party on August 6, 2010. Images of the Nissan were obtained from the auction facility's website after the sale and were used to conduct a partial exterior vehicle inspection.

Summary

Crash Site

The crash occurred during dawn in July 2010. At the time of the crash the weather was clear and the roadway was dry. The temperature at the nearest reporting station was 25.6° C (78.1° F) and winds were calm. The crash occurred within a four-leg intersection consisting of a north/south

roadway and an east/west roadway (**Figure 2**). The intersection was controlled by three-phase traffic signals.

Figure 2. Crash site, subject vehicle northbound approach to intersection

The south leg of the intersection consisted of five northbound lanes separated from two southbound lanes by a raised median. The northbound lanes included a right turn lane, two through lanes, and two left turn lanes. The travel lanes each measured 3.3 m (11.0 ft) in width and the raised median measured 1.8 m (5.9 ft) in width. The travel lanes were delineated by white reflective markers configured in a dashed pattern and the outboard road edges were bordered by solid white painted fog lines and raised concrete curbs. The roadway was straight in approach to the intersection and the profile changed from an uphill grade measuring 3.2 percent at 100.0 m (328.0 ft) south of the point of impact to level at the point of impact.

The west leg of the intersection consisted of five eastbound lanes separated from two westbound lanes by a raised median. The eastbound lanes were identical in configuration to the northbound lanes. The roadway alignment consisted of a slight left curve and the profile was a 2.0 percent uphill grade at the point of impact. The surface composition was asphalt and the speed limit was 56 km/h (35 mph) for both roadways. A crash scene diagram is included at the end of this report as Attachment 1.

Pre-Crash

The Toyota was traveling northbound in the outboard through lane and entered the intersection with a green signal. According to the vehicle's EDR, the Toyota's travel speed at Pre-Crash TGR[1] Event was 54.1 km/h (33.6 mph). The Nissan was traveling eastbound in the inboard through lane at an unknown speed and entered the intersection against a red signal. The Toyota crossed the path of the Nissan and both vehicles remained in their respective original travel lanes prior to impact. The scene inspection did not show evidence of pre-impact braking by the Nissan.

Crash

The crash sequence included one event as the front end of the Nissan impacted the left side passenger section of the Toyota. The directions of force for the impact were within the 10 o'clock sector for the Toyota and the 1 o'clock sector for the Nissan. The Toyota was displaced forward and right and the vehicle traveled 19.2 m (63.0 ft) to final rest in the westbound travel lanes. The Nissan traveled eastbound for approximately 6.1 m (20.0 ft) and came to rest in the eastbound lanes.

[1] Assumed to indicate Trigger

The area of impact showed a vehicle fluid spill beginning 8.4 m (27.6 ft) north of the south curb and 15.1 m (49.5 ft) west of the east curb. The final rest location for the Nissan showed a vehicle fluid spill beginning 7.2 m (23.6 ft) north of the south curb and 3.8 m (12.5 ft) east of the east curb.

For the Toyota, the Missing vehicle algorithm of WinSMASH calculated a Total Delta-V of 23.0 km/h (14.3 mph); the longitudinal and lateral components were -8.0 km/h (-5.0 mph) and 22.0 km/h (13.7 mph), respectively. The program calculated a Barrier Equivalent Speed (BES) of 25.0 km/h (15.5 mph). Based on the vehicle's crush profile, the WinSMASH results were reasonable. The vehicle's EDR reported a maximum lateral Delta-V of 26.2 km/h (16.3 mph)[2].

For the Nissan, WinSMASH calculated a Total Delta-V of 17.0 km/h (10.6 mph); the longitudinal and lateral components were -17.0 km/h (-10.6 mph) and -3.0 km/h (-1.9 mph), respectively. The program calculated a Barrier Equivalent Speed (BES) of 16.0 km/h (9.9 mph). Based on the partial inspection and estimated CDC, the WinSMASH results for the Nissan are considered to be borderline reconstruction.

Post-Crash

Following the crash, the driver of the Toyota was removed from his vehicle by on-scene responders through the front right door because the front left door was jammed shut. He was transported by ground to a local hospital trauma unit where he arrived 55 minutes post-crash at 0703 hours with a Glasgow Coma Score (GCS) of 15. He was treated for approximately 1 hour and discharged at 0810 hours. The driver did not receive any follow-up treatment.

The occupants of the Nissan were not transported. An evidentiary breath test revealed alcohol impairment by the driver of the Nissan. Both vehicles were towed due to damage.

Vehicle Data - 2008 Toyota Scion xB

The 2008 Toyota Scion xB was a four-door sport utility vehicle with a rear hatch. It was identified by the Vehicle Identification Number (VIN): JTLKE50E581xxxxxx and the date of manufacture was July 2007. The odometer reading obtained during the inspection was 72,005 km (44,742 mi). The vehicle was equipped with a 2.4-liter, 4-cylinder engine, manual 5-speed transmission, front-wheel drive, and power steering with tilt column functionality. Additional standard features included tinted rear windows, turn signals integrated into the side mirrors, 4-wheel anti-lock brakes (ABS) with Electronic Brake Distribution and Brake Assist, and Vehicle Stability Control with Traction Control.

The vehicle manufacturer recommended P205/55R16 tires for the front and rear with a cold tire pressure of 241 kPa (35 psi) for the front and 221 kPa (32 psi) for the rear. The Toyota was equipped with Bridgestone Turanza tires of the recommended size that were manufactured during June 2007 and mounted on original equipment manufacturer (OEM) ten-spoke aluminum rims. The specific tire data at the time of the vehicle inspection was as follows:

[2] The maximum post-crash Delta-V captured at B-Pillar Gy at 15 ms

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	200 kPa (29 psi)	4 mm (5/32 in)	No	None
LR	214 kPa (31 psi)	6 mm (8/32 in)	No	None
RR	207 kPa (30 psi)	6 mm (8/32 in)	No	None
RF	Tire flat	5 mm (6/32 in)	No	De-beaded

The Toyota's interior was equipped with fabric-covered five-passenger seating. The front row outboard bucket seats were configured with height-adjustable head restraints and separated by a center console with armrest. The driver's seat at the time of the inspection was set to the mid-to-rear track position, the seat back was slightly reclined, and the adjustable head restraint was set to the full-down position. The tilt steering wheel locking lever was in the open position and the steering column was in the full-down position.

Vehicle Damage - 2008 Toyota Scion xB

Exterior Damage

The Toyota sustained direct and induced damage to the left side and induced damage to the roof. The left front tire sustained a 2.0 cm (0.8 in) superficial cut and a 2.0 cm (0.8 in) rim scuff. The front right tire was flattened and de-beaded and the left side view mirror was displaced from the side door panel. The direct damage to the left side began 35.0 cm (13.8 in) forward of the left rear axle, extended forward 204.0 cm (80.3 in), and ended 21.0 cm (8.3 in) aft of the left front axle. The direct damage extended vertically from the sill to the belt line and measured 79.0 cm (31.1 in). The Field L began 8.0 cm (3.2 in) forward of the left rear axle, extended 236.0 cm (92.9 in) forward, and ended 16.0 cm (6.3 in) aft of the left front axle.

Figure 3. Side impact crush measurement, subject vehicle

Six crush measurements were taken at mid-door level (**Figure 3**) as follows: $C_1 = 0$ cm, $C_2 = 7.0$ cm (2.8 in), $C_3 = 28.0$ cm (11.0 in), $C_4 = 13.0$ cm (5.1 in), $C_5 = 13.0$ cm (5.1 in), $C_6 = 0$ cm. Maximum crush was located 102.0 cm (40.2 in) forward of the rear axle at C_3. The Collision Deformation Classification (CDC) for Event 1 was 10LPEW3.

The vehicle-to-vehicle impact resulted in direct damage to the Toyota's left A-pillar, B-pillar and side doors. The height of maximum door crush measured 47.0 cm (18.5 in), the sill height measured 26.0 cm (10.2 in), and the Door Sill Differential (DSD) was 24.0 cm (9.4 in).

Interior Damage - 2008 Toyota Scion xB

The Toyota sustained moderate interior damage resulting from impact forces, intrusion, and occupant contacts. The left front and rear side glass were disintegrated and the left side of the windshield was fractured. The left side doors were jammed shut and the front left window frame was deformed 26.0 cm (10.2 in) outboard resulting in integrity loss. The occupant compartment was reduced in size by lateral intrusion of the left side door panels, B-pillar, sill, roof side rail, front left seat back and cushion, front center console and left instrument panel (IP). It was reduced in size by vertical intrusion of the front left seat cushion and roof, and by longitudinal intrusion of the front left seat back. The front left safety belt components and the deployed left seat-mounted side impact air bag revealed scuff marks resulting from occupant loading, and the deployed left IC air bag was cut during post-crash activities. The front left door panel was scuffed and the steering column trim cover was displaced. Additionally, the front left seat cushion, seat back (**Figure 4**), and the center console were deformed by intrusion.

Figure 4. Driver's seat back deformed by left side intrusion, subject vehicle

Manual Restraint System - 2008 Toyota Scion xB

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-rings, and retractor pretensioners. The driver's safety belt was equipped with an Emergency Locking Retractor (ELR) and the front right passenger's safety had a switchable ELR/Automatic Locking Retractor (ALR).

Figure 5. Driver's safety belt showing scuff marks, subject vehicle

The driver's safety belt 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 and the webbing was locked in the spooled-out position. The safety belt webbing showed 20.0 cm (7.9 in) of scuff marks beginning 115.0 cm (45.3 in) above the stop button where the webbing was routed through the D-ring when it was loaded by the driver (**Figure 5**). The latch plate cover and D-ring also showed scuff marks from occupant loading. Based on the vehicle inspection it was determined that the front left safety belt was used to restrain the driver during the crash.

Supplemental Restraint System - 2008 Toyota Scion xB

The vehicle's Supplemental Restraint System (SRS) included an air bag control module (ACM), driver and passenger frontal air bags, seat-mounted side impact air bags, IC air bags, and safety belt retractor pretensioners for the front row. The vehicle manufacturer has certified that this model is compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system included dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, safety belt pretensioners, and a front right occupant weight-recognition sensor with an automatic air bag switch. The Toyota's advanced dual-stage frontal air bags were designed to deploy in two stages according to impact severity. The frontal air bags did not deploy.

Figure 6. Deployed left seat-mounted side impact air bag, subject vehicle

The left seat-mounted side impact air bag deployed at impact from the outboard aspect of the driver's seat back. The air bag was semicircular in shape measuring 42.0 cm (16.5 in) in height and 30.0 cm (11.8 in) in width. In its post-deflated state, the air bag excursion covered the left B-pillar and rear upper quadrant of the door panel including the armrest. The inboard panel of the air bag showed a 6.0 x 7.0 cm (2.4 x 2.8 in) area of scuff marks located 8.0 cm (3.1 in) aft of its forward edge and 15.0 cm (5.9 in) below the top edge (**Figure 6**). The outboard panel showed a 2.0 x 5.0 cm (0.8 x 2.0 in) scuff mark located mid-level at the forward aspect. The scuff marks were deposited by occupant loading during the crash.

The left IC air bag deployed from the roof side rail above the front and rear rows. The IC air bag was rectangular in shape and measured 180.0 cm (70.9 in) in length and 46.0 cm (18.1 in) in height. An external tether attached the forward aspect of the air bag to the left A-pillar. A 70.0 x 43.0 cm (27.6 x 16.9 in) front row section of the air bag had been cut out during post-crash activities. The removed section of the air bag was not inspected. The IC air bag did not show any evidence of occupant loading or other damage.

Event Data Recorder - 2008 Toyota Scion xB

The Toyota's EDR was imaged during the vehicle inspection by applying power to the vehicle's supplemental restraint system and connecting the Toyota EDR ROT to the Diagnostic Link Connector (DLC) port under the IP. The EDR module no. 89170-12580 was configured to capture pre-crash and post-crash data including two frontal crash events and two side impact crash events. The recorded data was imaged using software Version 1.4.1.0 and was reported using Version 1.4.1.1. The EDR data was summarized as follows:

Next Most Recent Pre-Crash Page 0[3]	
Occupant Data	
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	Belted
Occupant Detection	AM50[4]
Seat Position	RW[5]
Shift Position	Invalid
PAB Manual Cut Off (N/A)	(N/A)
R/O CSA-Manual Cut Off (N/A)	(N/A)
Writing Flag for Pre-Crash/Occupant	Finished Writing

Pre-Crash Data						
Time (sec)	-5	-4	-3	-2	-1	0
Speed (mph)	3.7	2.5	2.5	3.7	5.0	6.2
Brake	ON	OFF	OFF	OFF	OFF	ON
Accelerator	OFF	OFF	OFF	OFF	OFF	OFF
Engine (rpm)	400	800	800	800	1200	1600

Latest Pre-Crash Page1	
System Information	
Page No. of Latest Pre-Crash Data	Page.1
Time from Previous Pre-Crash TRG Event	16381
Freeze Signal	Freeze
AB Deployment Flag	SAB for Driver

[3] Next Most Recent Pre-Crash Page 0 and Pre-Crash data refers to a prior event and was not associated with this crash. There was no frontal Delta-V reported for this crash.

[4] Assumed to indicate American Male 50% percentile, weight classification

[5] Assumed to indicate Rearward

Occupant Data	
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	Unbelted
Occupant Detection	Unoccupied
Seat Position	RW
Shift Position	Invalid
PAB Manual Cut Off (N/A)	(N/A)
Writing Flag for Pre-Crash/Occupant	Finished Writing

Pre-Crash Data						
Time (sec)	-5	-4	-3	-2	-1	0
Speed (mph)	38.5	38.5	38.5	38.5	33.6	33.6
Brake	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator	OFF	OFF	OFF	OFF	OFF	OFF
Engine (rpm)	2000	2000	2000	2000	1600	1600

Frontal Crash Page 0	
Max delta-Vx	3.1 (mph)[6]
TGR Counter	1 (times)
Previous Event	No Event
Linked Pre-Crash Date Page No.	Page 0
Time from Pre-Crash to TGR	0 milliseconds (ms)
Frontal AB Deployment Time	Not Fired
Pretensioner Deployment Time	Not Fired
Deployment Stage Driver	Not Fired
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

[6] Maximum Post-crash Delta-V occurred at 200 ms

Frontal Crash Page 1	
Max Delta-Vx	0.0 (mph)
TGR Counter	0 (times)
Previous Event	Frontal
Linked Pre-Crash Date Page No.	Page 0
Time from Pre-Crash to TGR	0 (ms)
Frontal AB Deployment Time	0 (ms)
Pretensioner Deployment Time	Not Fired
Deployment Stage Driver	Not Fired
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

Side Crash Page 0	
Post-Crash Data (Vel Chg) B-Pillar	16.3 (mph) at 15 ms[7]
Post-Crash Data (Vel Chg) C-Pillar	28.3 (mph) at 75 ms
Post-Crash Data (Vel Chg) Floor	-13.2 (mph) at 75 ms
Time from TGR to Initial G	3 (ms)
TGR Counter	2 (times)
Previous Event	No Event
Linked Pre-Crash Date Page No.	Page 1
Time from Pre-Crash to TGR	0 (ms)
Deployment Time (B-Pilllar)	0 (ms)
Deployment Time (C-Pilllar)	16 (ms)
Deployment Side	Driver's side
Writing Flag for Side Crash	Finished Writing

[7] Velocity Changes for B-pillar, C-pillar, and Floor represent the maximum recorded values

Side Crash Page 1	
Post-Crash Data (Vel Chg)	0.0
Time from TGR to Initial G	0 (ms)
TGR Counter	0 (times)
Previous Event	Frontal
Linked Pre-Crash Date Page No.	Page 0
Time from Pre-Crash to TGR	0 (ms)
Deployment Time (B-Pilllar)	0 (ms)
Deployment Time (C-Pilllar)	16 (ms)
Deployment Side	Driver's side
Writing Flag for Side Crash	Finished Writing

Vehicle Data - 2008 Nissan Frontier

The 2008 Nissan Frontier Crew Cab pickup (**Figure 7**) was identified by the VIN:1N6AD07W58Cxxxxxx and the date of manufacture was November 2007. The vehicle was equipped with a 4.0-liter, 6-cylinder engine, 4-wheel driver, 4-wheel anti-lock brakes, and power steering. The odometer reading was 89,348 km (55,520 mi). The vehicle manufacturer recommended P265/70R16 tires for the front and rear with a tire pressure of 241 kPa (35 psi) for the front and rear.

Figure 7. Other vehicle, 2008 Nissan Frontier (auction facility photo)

Exterior Damage - 2008 Nissan Frontier

The Nissan sustained damage to the front end, hood, forward aspect of the left and right front fenders, and engine compartment during the crash. The front grille and bumper fascia were displaced from the vehicle and the hood was buckled. This inspection was photo-based so no specific damage measurements were possible. The Nissan's estimated CDC based on photographs was 12FDEW2.

Occupant Demographics - 2008 Toyota Scion xB

Driver

Age/Sex:	42 years/Male
Height:	175 cm (69 in)
Weight:	94 kg (207 lb)
Seat type:	Bucket with adjustable head restraint
Seat track position:	Mid-to-rear track
Manual restraint usage:	Lap and shoulder belt used properly
Usage source:	Vehicle inspection
Air bags:	Seat-mounted side impact air bag and IC air bag deployed; frontal air bag not deployed
Alcohol, drug involvement:	None
Type of medical treatment:	Transported, treated and released

Occupant Kinematics - 2008 Toyota Scion xB

Driver

The 42-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.

At impact with the Nissan, the Toyota's left seat-mounted side impact air bag and left IC air bag deployed and the driver's safety belt pretensioner actuated. The driver was displaced left and slightly forward in response to the 10 o'clock direction of force. His shoulder, chest and abdomen loaded the safety belt causing scuffs to the D-ring, webbing and latch plate. His left flank loaded the seat-mounted side impact air bag and left door panel depositing scuffs to the inboard and outboard sides of the air bag. The driver's left upper arm loaded the rear upper quadrant of the door panel causing contusions and leaving scuff marks on the door panel trim.

The front left door panel and left B-pillar intruded laterally into the occupant compartment displacing and deforming the driver's seat cushion and seat back. The seat cushion was displaced laterally 10.0 cm (3.9 in) to the right, its leading edge was displaced vertically 4.0 cm (1.2 in) upward, and its forward-facing orientation was displaced 10 degrees counterclockwise. The seat back was displaced laterally 13.0 cm (5.1 in) to the right and its orientation was displaced 15 degrees counterclockwise. The driver's left hip contacted the rear lower quadrant of the left door panel causing a left hip contusion. His right hip contacted the center console, displacing it to the right. The Toyota was

displaced forward and right and the driver was held in place in his seat by the safety belt's actuated pretensioner until the vehicle came to rest in the intersection. Before exiting the vehicle with assistance from responders, the driver complained of chest pains.

Occupant Injuries

Driver

Injury	Injury Severity AIS 05/Update 08	Injury Mechanism	Confidence Level
Abrasions, left shoulder (clavicle)	710202.1,2	Safety belt webbing	Certain
Contusions, left upper arm	710402.1,2	Left door panel, rear upper quadrant	Certain
Abrasions, abdomen	510202.1,4	Safety belt webbing	Certain
Contusion, left hip	810402.1,2	Left door panel, rear lower quadrant	Certain

Attachment 1. Scene Diagram