

On-Site Side Air Bag Investigation
Dynamic Science, Inc. (DSI), Case Number DS09033
2008 Toyota Corolla
Washington
October 2009

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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.

1. Report No. DS09033		2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle On-Site Side Air Bag Investigation				5. Report Date April 2, 2010	
				6. Performing Organization Report No.	
7. Author(s) Dynamic Science, Inc.				8. Performing Organization Report No.	
9. Performing Organization name and Address Dynamic Science, Inc. 299 West Cerritos Avenue Anaheim, CA 92805				10. Work Unit No. (TRAIS)	
				11. Contract or Grant no. DTNH22-07-00045	
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NVS-411) National Highway Traffic Safety Administration 1200 New Jersey Ave, SE Washington, DC 20590				13. Type of report and period Covered [Report Month, Year]	
				14. Sponsoring Agency Code	
15. Supplemental Notes					
16. Abstract This on-site side air bag investigation focused on the air bag deployments in a 2008 Toyota Corolla involved in a two-vehicle crash. The crash occurred in October 2009 at 0849 hours in the state of Washington. The subject vehicle was being driven by a 41-year-old male. The other vehicle was a 2005 Thomas Built school bus that was being driven by a 41-year-old male. There were 31 students on the bus at the time of the crash. The crash site was a four-leg intersection. The Toyota was traveling southbound and entered the intersection; the bus was traveling westbound and the driver reported that he stopped his vehicle at the stop sign before entering the intersection. The front end of the bus impacted the left side of the Toyota. The Toyota was equipped with seat-mounted side air bags for the front row and side impact inflatable curtain (IC) air bags for the front and second rows. At impact, the left IC air bag and left seat-mounted side air bags deployed. The Toyota was displaced to the right and impacted a pole located at the southwest corner of the intersection. The driver of the Toyota had no obvious injuries but did complain that his back was sore. The driver and student passengers of the bus did not report any injuries. The Toyota was towed from the scene due to damage and was later declared a total loss by the insurance company. The bus was driven from the scene.					
17. Key Words Side air bag, deployment, no injuries			18. Distribution Statement		
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price		

Dynamic Science, Inc.
Crash Investigation
Case Number: DS09033

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BACKGROUND

This on-site side air bag investigation focused on the air bag deployments in a 2008 Toyota Corolla involved in a two-vehicle crash (**Figure 1**). The crash occurred in October 2009 at 0849 hours in the state of Washington. The subject vehicle was being driven by a 41-year-old male. The other vehicle was a 2005 Thomas Built school bus that was being driven by a 41-year-old male. There were 31 students on the bus at the time of the crash. The crash site was a four-leg intersection. The Toyota was traveling southbound and entered the intersection; the bus was traveling westbound and the driver reported that he stopped his vehicle at the stop sign before entering the intersection. The front end of the bus impacted the left side of the Toyota. The Toyota was equipped with seat-mounted side air bags for the front row and side impact inflatable curtain (IC) air bags for the front and second rows. At impact, the left IC air bag and left seat-mounted side air bag deployed. The Toyota was displaced to the right and impacted a pole located at the southwest corner of the intersection. The driver of the Toyota had no obvious injuries but did complain that his back was sore. The driver and student passengers of the bus did not report any injuries. The Toyota was towed from the scene due to damage and was later declared a total loss by the insurance company. The Thomas Built bus was driven from the scene.



Figure 1. Subject vehicle, 2008 Toyota Corolla

This on-site side air bag investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) during a review of National Automotive Sampling System (NASS) General Estimates System (GES). On October 30, 2009, DSI was forwarded the police report and directed to commence the investigation. DSI obtained permission to inspect the subject vehicle and the case was assigned on November 5, 2009. The vehicle was inspected at an insurance auction facility on November 11, 2009. Permission to remove the vehicle's Event Data Recorder (EDR) was denied by the insurance company.

SUMMARY

Crash Site

The crash site was a four-leg intersection consisting of a north/south roadway and an east/west roadway. The north/south roadway was configured with single through lanes in each direction (**Figure 2**). The through lanes were separated by a dashed yellow stripe. The roadway was controlled by three-phase traffic signals that were in the green phase at the time of the crash. The roadway surface was concrete, the alignment was straight, and the grade was a positive 1.5



Figure 2. Southbound approach

percent 15.2 m (50.0 ft) north of the intersection. The west leg of the intersection was configured with two unmarked through lanes (**Figure 3**). The roadway was controlled by a stop sign. The roadway surface was concrete, the alignment was straight, and the grade was a negative 4.4 percent 15.2 m (50 ft) east of the intersection. The speed limit in all directions was 48 km/h (30 mph).

Pre-Crash

At the time of the crash it was raining. The Toyota traveling southbound and entered the intersection; the Thomas Built bus was traveling westbound and the driver reported that he stopped his vehicle at the stop sign before entering the intersection.



Figure 3. Eastbound approach

Crash

The vehicles entered the intersection and the front end of the Thomas Built bus impacted the left side of the Toyota. The bus was out of scope for the WinSMASH program. For informational purposes, the Barrier algorithm of the WinSMASH was run and computed a Total Delta-V of 15.0 km/h (9.3 mph) based on the Toyota's left side crush profile. The longitudinal and lateral components were -13.0 km/h (-8.1 mph) and 7.5 km/h (4.7 mph), respectively. At the impact, the left IC air bag and left seat-mounted side air bag deployed. The impact to the Toyota was slightly rearward of the vehicle's center of gravity and the vehicle initiated a counterclockwise rotation. The Toyota was displaced to the right and impacted a pole located at the southwest corner of the intersection. A crossing guard working at the intersection was interviewed and he stated that the impacted pole was a metal sign post that identified the street names. The street sign posts in the area were square metal poles measuring 5.0 cm (2.0 in). The pole was displaced which invalidated WinSMASH because it was a yielding object. For informational purposes, the Barrier algorithm of the WinSMASH was run and computed a Total Delta-V of 13.0 km/h (8.1 mph) based on the vehicle's right side crush profile. The longitudinal and lateral components were -2.3 km/h (-1.4 mph) and -12.8 km/h (-8.0 mph), respectively. The results for the WinSMASH run should be considered borderline.

Post-Crash

The driver of the Toyota had no obvious injuries but did complain that his back was sore. The driver and student passengers of the bus did not report any injuries. All the students were transferred to a different school bus and transported to school. The Toyota was towed from the scene due to damage and was later declared a total loss by the insurance company. The Thomas Built bus was driven from the scene. The police reported that the stop stick on the front of the bus was damaged. The bus was not inspected.

Vehicle Data - 2008 Toyota Corolla

The subject vehicle was a 2008 Toyota Corolla S 4-door sedan. The Toyota was identified by the Vehicle Identification Number (VIN): 1NXBR30E58Zxxxxxx and the date of manufacture was October 2007. The odometer reading was 24,051 km (14,945 miles). The vehicle was equipped with a 1.8-liter, 4-cylinder engine, automatic transmission, front wheel drive, front disc/rear drum brakes, and power steering and tilt column functionality.

The vehicle manufacturer's recommended tire size was P195/65R15 and the recommended cold tire pressure was 207 kPa (30 psi). The vehicle was equipped with Bridgestone Insignia SE P195/65R15 tires that had a tire manufacturer's recommended maximum tire pressure of 276 kPa (40 psi). The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	193 kPa (28 psi)	5 mm (6/32 in)	No	None
LR	Tire Flat	6 mm (7/32 in)	No	Tear in sidewall
RR	Tire Flat	7 mm (9/32 in)	No	None
RF	200 kPa (29 psi)	6 mm (7/32 in)	No	None

The Toyota's interior was configured with seating for five occupants. The front row consisted of outboard bucket seats with adjustable head restraints. The second row consisted of a 60/40 split bench seat with folding backs and adjustable head restraints for the three seat positions.

Vehicle Damage

Exterior Damage

The Toyota sustained direct and induced damage to the left side as a result of the impact with the Thomas Built bus (**Figure 4**). Direct damage began 25.0 cm (9.8 in) aft of the rear axle and extended forward 209.0 cm (82.2 in). The Field L began 25.0 cm (9.8 in) aft of the rear axle and extended forward 200.0 cm (78.7 in). Vertically, the direct damage began 20.0 cm (7.9 in) above the sill and extended upward 56 cm (22.0 in) to the belt line. Six crush measurements were documented at the mid-door level: $C_1 = 0$ cm, $C_2 = 8.0$ cm (3.1 in), $C_3 = 11.0$ cm (4.3 in), $C_4 = 7.0$ cm (2.8 in), $C_5 = 6.0$ cm (2.4 in), $C_6 = 0$ cm. Maximum crush was located between C_3 and C_4 and measured 12.0 cm (4.7 in). The Collision Deformation Classification (CDC) was 11LZEW2. The Toyota sustained direct contact to the



Figure 4. Left side damage

second row door panel from the impact with the bus. The Toyota's sill height measured 28.0 cm (11.0 in), height of maximum door crush measured 62.0 cm (24.4 in), and the Door Sill Differential (DSD) measured 10.0 cm (3.9 in).

The Toyota sustained direct and induced damage from the impact with the pole (**Figure 5**). Direct damage began 40.0 cm (15.7 in) aft of the rear axle and extended forward 56.0 cm (22.0 in). The Field L began 66.0 cm (25.9 in) aft of the rear axle and extended forward 96.0 cm (37.8 in). Six crush measurements were documented at the mid-door level: $C_1 = 0$ cm, $C_2 = 6.0$ cm (2.4 in), $C_3 = 12.0$ cm (4.7 in), $C_4 = 8.0$ cm (3.1 in), $C_5 = 8.0$ cm (3.1 in), $C_6 = 0$ cm. The CDC for this impact was 03RBAW2.



Figure 5. Right side damage

Interior Damage

The Toyota sustained minor interior damage as a result of intrusions and occupant contacts. Lateral intrusion was located in the second row at the armrest and rearward lower quadrant of the left door panel. Evidence of occupant loading and contacts were documented to the steering column, left door panel, seat back, instrument panel, left seat-mounted side air bag, left IC air bag, and the driver's safety belt.

The vehicle's glazing remained intact and the vehicle did not sustain any integrity loss. The second row left door was jammed shut.

Manual Restraints

The front row seating positions were equipped with 3-point manual lap and shoulder belts with sliding latch plates, adjustable D-rings, and retractor pretensioners. The driver's safety belt had an Emergency Locking Retractor (ELR) and the front right passenger's safety belt had a switchable ELR/Automatic Locking Retractor (ALR).

The driver's safety belt D-ring anchorage was in the full-up position. The latch plate was scratched and the shoulder belt revealed wear marks indicating historical usage. There was an area of fraying that measured 15.0 cm (5.9 in) and was located 60.0 cm (23.6 in) from the anchorage (**Figure 6**). The safety belt pretensioner did not actuate in this crash.



Figure 6. Area of fraying to driver's safety belt webbing

The right side safety belt was equipped with an ELR/ALR retractor. The safety belt pretensioner did not actuate during the crash. The latch plate revealed scratches indicating historical usage. The three second seat safety belts were equipped with ELR/ALR retractors. There were no indications of historical usage.

Supplemental Restraint Systems

The vehicle's Supplemental Restraint System (SRS) included an air bag control module (ACM), driver and passenger frontal air bags, seat-mounted side air bag for the front row, side impact inflatable curtain (IC) air bags, and safety belt retractor pretensioners. The Toyota was a Certified Advanced 208-Compliant (CAC) vehicle. A CAC vehicle is certified by the manufacturer to be compliant with the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

During the impact with the bus the left seat-mounted side air bag and left IC air bags deployed. The right IC air bag deployed during the impact with the pole. There were no frontal air bag or right seat-mounted air bag deployments.

The left seat-mounted side air bag deployed from a module located in the left seat-back (**Figure 7**). The air bag was oval in shape and measured 40.0 cm (15.7 in) in height and 30.0 cm (11.8 in) in width. The air bag was configured with three vent ports located in the non-inflatable section of the air bag. The air bag was configured without internal tethers. A 8.0 x 5.0 cm (3.1 x 1.9 in) skin oil transfers was located toward the middle of the air bag. On the outboard portion of the air bag there was a 4.0 x 4.0 cm (1.6 x 1.6 in) area of black marks that were a result of contact with the interior door surface.

The left IC air bag deployed from a module in the left roof rail above the front and second rows. The IC air bag measured 156.0 cm (61.4 in) in length, 48.0 cm (18.9 in) in height, and extended 16.0 cm (6.3 in) below the window frame. Two areas of possible skin contacts were located on the interior of the air bag near the B-pillar (**Figure 8**). The right IC deployed from a module in the right roof rail above the front and second rows. The air bag was configured the same as the driver's side; there was no damage to the air bag and no contacts identified.



Figure 7. Driver seat-mounted side air bag



Figure 8. Left IC air bag and possible contacts

Vehicle Data - 2005 Thomas Built School Bus

The other vehicle was a 2005 Thomas Built school bus. The bus was identified by the VIN: 4UZAAXDC55Cxxxxxx. The bus was built on Freightliner FS6 incomplete chassis with a cab-behind-engine design. The bus was equipped with a 7.1-liter, 6-cylinder engine, automatic transmission, and rear-wheel drive. The vehicle sustained minor scraping type damage to the front bumper and the passenger stop stick was displaced (**Figures 9-10**). The driver and student passengers of the bus did not report any injuries. All the students were transferred to a different school bus and transported to school. The involved bus was driven from the scene.



Figure 9. Front right damage (owner photo)



Figure 10. Front left (owner photo)

OCCUPANT DEMOGRAPHICS

	Driver
Age/Sex:	41/Male
Seated Position:	Front left
Seat Type:	Bucket
Seat Track Position:	Full-rear
Height:	Unknown
Weight:	Unknown
Alcohol/Drug Involvement:	None
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Left on floor, right on accelerator
Restraint Usage:	Lap and shoulder belt

Occupant Injuries

There were no reported injuries.

Occupant Kinematics

The 41-year-old male driver was seated in an unknown posture and was restrained by the vehicle's lap and shoulder belt. His seat back was slightly reclined and the seat cushion was set to the rearmost track position at the time of the vehicle inspection. It is not known if the driver saw the other vehicle or took any evasive maneuvers.

At impact with the bus, the left seat-mounted side air bag and IC air bag deployed. The driver was displaced forward and left in response to the direction of force. He loaded the safety belt and contacted the deployed side air bag and IC air bag. He contacted the steering column with his right knee and the left door panel with his left knee (**Figure 11**). During the right side impact he was slightly displaced to the right but remained belted within his seat. The driver of the Toyota had no obvious injuries but did complain that his back was sore.



Figure 11. Left knee contact to door panel

