On-Site Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS10026
2010 Scion xD
California
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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15. Supplemental Notes

This on-site investigation focused on the rollover dynamics of a 2010 Scion xD involved in a vehicle-to-vehicle crash with a Toyota Prius and subsequent rollover, and the injuries sustained by the adult male driver of the Scion.

16. Abstract

The crash occurred in a T-intersection during September 2010 in the state of California. The Scion was being driven northbound by a restrained 21-year-old male and the Toyota was being driven southbound by a restrained 57-year-old male. The Scion entered the intersection, initiated a left turn across the path of the Toyota, and the front end of the Toyota impacted the right side of the Scion. Following the initial impact, the Scion initiated a two quarter-turn rollover. It came to rest on its roof and facing northwest in the southbound lanes. The driver of the Scion sustained serious injuries and was transported to a local hospital where he was hospitalized for three days. The Prius came to rest facing west at the southwest corner of the intersection. The driver of the Toyota sustained multiple unspecified injuries and was transported to a local hospital where he was declared deceased. Both vehicles were towed due to damage and were later declared total losses by their respective insurance companies.

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Dynamic Science, Inc.
Crash Investigation
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TABLE OF CONTENTS

BACKGROUND

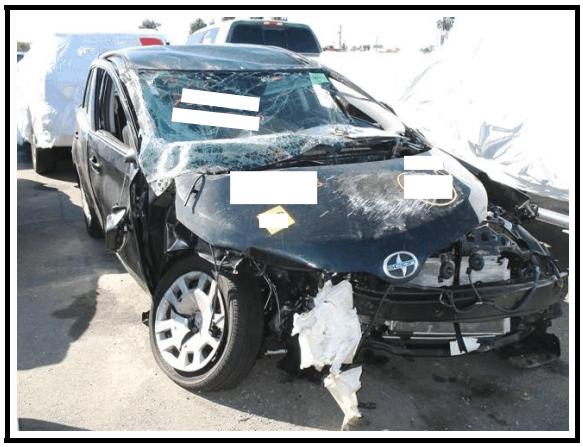

Figure 1. 2010 Scion xD

This on-site investigation focused on the rollover dynamics of a 2010 Scion xD (**Figure 1**) involved in a vehicle-to-vehicle crash and subsequent rollover, and the injuries sustained by the adult male driver. The crash was identified by a DSI investigator during a review of an auto auction sale list. On October 11, 2010, DSI forwarded images of the Scion to the National Highway Traffic Safety Administration (NHTSA) for review and DSI was instructed to commence the investigation. Permission to inspect the Scion was obtained from the insurance company, the police report was obtained from the investigating police agency, and the case was assigned on November 19, 2010. The Scion was located at an auto auction facility and the vehicle inspection was completed on November 22, 2010. The Scion's Event Data Recorder (EDR) was supported by the Toyota Readout Tool (ROT) and the crash data was imaged during the vehicle inspection using ROT software version 1.4.1.1. The other vehicle involved in the crash was a 2010 Toyota Prius. Permission to inspect the Toyota was obtained from the insurance company and the vehicle was inspected on November 30, 2010. The Toyota's EDR was supported by the Toyota ROT and the crash data was imaged during the inspection. Summaries of the vehicles' EDR data were incorporated into this report.

The crash occurred in a T-intersection during September 2010 in the state of California. The Scion was being driven northbound by a restrained 21-year-old male and the Toyota was being driven southbound by a restrained 57-year-old male. The Scion entered the intersection, initiated a left turn across the path of the Toyota, and the front end of the Toyota impacted the right side of the Scion. Following the initial impact, the Scion initiated a two quarter-turn rollover.

Following the rollover, the Scion came to rest on its roof and facing northwest in the southbound lanes. The driver of the Scion sustained serious injuries and was transported to a local hospital where he was hospitalized for three days. The Toyota came to rest facing west at the southwest corner of the intersection. The driver of the Toyota sustained multiple unspecified injuries and was transported to a local hospital where he was declared deceased. Both vehicles were towed due to damage and were later declared total losses by their respective insurance companies.

CRASH SUMMARY

Crash Site

The crash occurred in a T-intersection consisting of a north/south roadway and an east/west roadway. Conditions at the time of the crash were daylight, clear, and dry. The intersection was controlled by three-phase traffic signals and the posted speed limit was 64 km/h (40 mph). The temperature at the nearest reporting station was 10.8° C (87.1° F), winds were calm, and visibility was 16.1 km (10.0 mi). The south leg of the intersection consisted of two northbound lanes, two southbound lanes, and a left turn lane (**Figure 2**). The travel lanes were separated by single white painted stripes and the left turn lane was separated from the southbound lanes by a double yellow painted stripe. The

roadway edges were bound by solid white painted fog lines and unpaved ground. The asphalt roadway surface was in good condition. The northbound roadway was straight wit a slight downhill slope measuring -1.6 percent at 61.0 m (200 ft) south of the intersection and level at the point of impact.

The north leg of the intersection consisted of two northbound lanes, two southbound lanes, and a two-way center left turn lane. The lanes were separated by solid white painted stripes and the left turn lane was bordered by double yellow painted stripes. The southbound roadway was straight and level.

Figure 2. Crash site, looking north from left turn lane

The west leg of the intersection consisted of one eastbound lane, one westbound lane, and a left turn lane. The roadway was straight and level. The intersecting roadways were bordered by raised concrete curbs measuring 14.0 cm (5.5 in) in height. Based on the police report there were no unusual conditions at the time of the crash. A scene diagram is included at the end of this report.

Pre-Crash

According to the police report, the traffic signals at the intersection were in the green phase for the northbound and southbound lanes, including the left turn lane occupied by the Scion. The Scion was traveling northbound in the left turn lane and initiated a left turn across the path of the Toyota at an EDR-reported speed of 29.9 km/h (18.6 mph)[1]. The Toyota was traveling southbound in the first lane from the right and entered the intersection at an EDR-reported speed of 122.0 km/h (75.8 mph)[2]. Based on the driver interview, the driver of the Scion observed the Toyota moments before impact and attempted to accelerate through the intersection and evade the impact. This attempt to evade by accelerating was reflected in the Scions' EDR report, which indicated the vehicle speed increased from (16.2 mph) at -1 second to (18.6 mph) at -200 ms to Trigger (TGR). Additionally, the Scion's brake light switch was activated from -2 seconds to -3 seconds to TGR, and the brake switch was not activated from -1 second to -200 ms to TGR.

The Toyota's EDR report did not indicate pre-crash braking. It did indicated a reduction in engine speed from 4000 RPM at -3 seconds to TGR to 2000 RPM at -200 ms to TGR.

Crash

The crash sequence included two events beginning with a front-to-side angle impact in which the front end of the Toyota impacted the right side front sector of the Scion (Event 1). During the first event, the driver's frontal air bag deployed and his safety belt retractor pretensioner actuated. The point of impact was located based on police markings in the intersection in the first southbound lane

[1] Speed measured at the time of pre-crash TGR (assumed to mean Trigger)

[2] Speed measured at the time of pre-crash TGR

from the right. Following the impact, the Scion rotated counterclockwise and initiated a left side leading trip rollover (Event 2) and after rolling two quarter-turns came to rest on its roof in the first southbound lane from the right (**Figure 3**). Evidence of the trip included a fracture to the Scion's left front rim and scuff marks to the tire indicating contact with the roadway. A scrape mark on the roadway deposited by the Scion during the rollover measured 30.0 cm (12.0 in) in length and was located 20.7 m (69.9 ft) south of the area of the first impact. The roll distance was estimated to be 21.0 m (69.0 ft).

Figure 3. Look back from final rest to rollover and impact, 2010 Scion xD

The Toyota was displaced to the left and traveled 16.1 m (52.8 ft) to the southwest corner of the intersection where it came to rest facing southwest with its front tires on the curb and its rear tires in the southbound lane.

For the Scion in Event 1 the Standard algorithm of the WinSMASH program calculated a Total Delta-V of 62.0 km/h (38.5 mph); the longitudinal and lateral components were -54.0 km/h (-33.6 mph) and -31.0 km/h (-19.3 mph). The program calculated a Barrier Equivalent Speed (BES) of 36.0 km/h (22.4 mph). Based on the vehicle's crush profile the WinSMASH results were considered reasonable. The vehicle's EDR reported a maximum longitudinal Delta-V of 63.2 km/h (39.6 mph) and a maximum lateral Delta-V of 37.5 km/h (23.3 mph).

For the Toyota in Event 1 the Standard algorithm of the WinSMASH program calculated a Total Delta-V of 57.0 km/h (35.4 mph); the longitudinal and lateral components were -56.0 km/h (-34.8 mph) and 10.0 km/h (6.2 mph). The program calculated a BES of 74.0 km/h (46.0 mph). Based on the vehicle's crush profile the WinSMASH results were considered reasonable. The vehicle's EDR reported a maximum longitudinal Delta-V of 51.5 km/h (32.0 mph).

Rollover impacts are beyond the scope of WinSMASH and a Delta-V could not be calculated for the Scion in Event 2. Based on the CDC for the rollover, the estimated severity of damage was moderate.

Post-Crash

The Scion came to rest on its roof. Based on the driver interview, the driver of the Scion unbuckled his pretensioned safety belt and exited the vehicle unassisted through the front row left side window. He waited on the roadside for several minutes until responders arrived and then he was transported to a local hospital where he arrived at approximately 1110 hours with a Glasgow Coma Score (GCS) of 15. The driver was admitted, treated for three days, and discharged. He continued to receive follow-up treatment including physical therapy for several months.

The driver of the Toyota was removed from his vehicle by on-scene responders. He was transported to a local hospital where he was pronounced deceased upon arrival. The vehicles were towed due to damage and were later declared total losses by their respective insurance companies.

2010 SCION xD

Description

The 2010 Scion xD was a five-door hatchback identified by the Vehicle Identification Number (VIN): JTKKU4B45AJxxxxxx and its date of manufacture was November 2009. The odometer reading was unknown due to the inoperable electronic odometer but the driver estimated the mileage to be approximately 9,656 km (6,000 mi). The vehicle was equipped with a 1.8-liter, 4-cylinder engine, 4-speed automatic transmission, front wheel drive, and power steering with tilt column functionality. Additional standard features included 4-wheel anti-lock brakes (ABS) with electronic brake-force distribution (EBD) and brake assist, stability control, traction control, and a tire pressure monitoring system.

The vehicle manufacturer recommended P195/60R16 tires for the front and rear with a cold tire pressure of 228 kPa (33 psi) for the front and rear. The Scion was equipped with Bridgestone Turanza EL400 tires of the recommended size front and rear and they were mounted on original equipment manufacturer (OEM) steel rims. The tires were manufactured in November 2009. The specific tire data at the time of the vehicle inspection was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	193 kPa (28 psi)	6 mm (8/32 in)	No	Tire de-beaded
LR	179 kPa (26 psi)	6 mm (8/32 in)	No	None
RR	186 kPa (27 psi)	6 mm (8/32 in)	No	None
RF	Tire flat	6 mm (8/32 in)	Yes	Tire de-beaded

The Scion's interior was equipped with fabric-covered five-passenger seating. The front row left and right 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 Scion sustained direct and induced damage to the right side and induced damage to the front, left, and top planes during the vehicle-to-vehicle impact (Event 1). The front right rim was canted inboard, the front right tire was flattened, and the front bumper fascia and grille were displaced from the vehicle. The direct damage to the right side began at the right A-pillar, 207.0 cm (81.5 in) forward of the rear axle and extended 79.0 cm (31.1 in) forward to the right edge of the front bumper backing bar. The Field L also measured 79.0 cm (31.1 in). Six crush measurements were taken at lower-door level as follows: C_1 = 7.0 cm (2.8 in), C_2 = 12.0 cm (4.7 in), C_3 = 34.0 cm (13.4 in), C_4 = 44.0 cm (17.3 in), C_5 = 61.0 cm (24.0 in), C_6 = 63.0 cm (24.8 in) (**Figure 4**). Maximum crush was located at C6. The Collision Deformation Classification (CDC) for Event 1 was 01RFEW4. Based on the CDC, the damage severity to the Scion in Event 1 was severe.

The Scion sustained direct damage to the left side and top planes during the rollover (Event 2). Direct damage to the roof was distributed laterally from roof side rail to roof side rail along the

windshield header and measured 110.0 cm (43.3 in). Direct damage to the hood was distributed laterally from side to side and measured 130.0 cm (51.1 in). Direct damage to the top plane began at the leading edge of the hood and extended 170.0 cm rearward to the B-pillar sector of the roof and continued along the roof side rails to the C-pillars. Direct damage to the left side began 34.0 cm (13.4 in) aft of the rear axle and extended 309.0 cm (121.6 in) forward. Vertically, the left side direct damage extended from the lower door to the roof side rail.

Figure 4. Right side crush measurement, 2010 Scion xD

Maximum vertical crush to the greenhouse was located on the left windshield header at 5.0 cm (2.0 in) right of the left roof side rail and measured 9.0 cm (3.5 in) (**Figure 5**). Maximum lateral crush to the greenhouse was located on the left roof side rail at 160.0 cm (63.0 in) forward of the rear axle and measured 17.0 cm (6.7 in). The CDC for Event 2 was 00TDDO2.

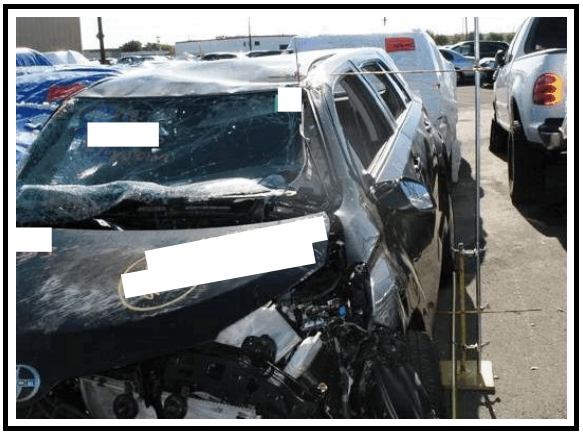

Figure 5. Roof crush measurement, 2010 Scion xD

Event Data Recorder

The Scion's EDR was imaged and reported using software version 1.4.1.1. During the vehicle inspection the Toyota EDR ROT was connected directly to the EDR module number 89170-52B30. The EDR was configured to capture pre-crash data, two frontal events, and two side events. It was not configured to capture rollover events. The EDR data was summarized as follows:

Latest Pre-Crash Page.1	
Record Status	Recorded
System Information	
Page No. Of Latest PreCrash Data	Page.1
Time From Previous PreCrash TRG[3] Event	16381 (ms)
Freeze Signal	Freeze
AB Deployment Flag	FrontalAB&Pretensioner

[3] Assumed to mean Trigger

Diagnostic	
Writing Flag for Diag	Finished Writing
Occupant	
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	UnBelted
Occupant Detection	Unoccupied
Seat Position	RW[4]

Shift Position	Others[5]
PAB Manual Cut Off (N/A)	(N/A)
R/O CSA-Manual Cut Off (N/A)	(N/A)
Writing Flag for PreCrash/Occupant	Finished Writing

PreCrash Data[6]						
	-5[7]	-4	-3	-2	-1	0
Speed	16.2	17.4	17.4	16.2	16.2	18.6 (mph)
Brake	OFF	OFF	ON	ON	OFF	OFF
Accelerator	1.17 OFF	0.78 OFF	0.78 OFF	0.78 OFF	3.44 FULL	3.44 FULL
Engine	1200	800	800	800	2400	2400 (rpm)
Time from Last PreCrash Data: 200 (ms)						

Frontal Crash Page.1	
Record Status	Recorded

[4] Assumed to mean Rearward

[5] Does not indicate Park, Reverse or Neutral shift positions

[6] Associated with frontal air bag deployment event

[7] Time measured in seconds

Max delta Vx	39.6 (mph)[8]
Writing Flag for Gx	Finished Writing
TRG Counter	2 (times)
Previous Event	No Event
Linked PreCrash Data Page No.	Page.1
Time from PreCrash TRG	0 (ms)
Frontal AB Deployment Time	7 (ms)
Pretensioner Deployment Time	7 (ms)
Deployment Stage Driver	Low
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

Side Crash Page.0	
Record Status	Recorded
Time From TRG to Initial G	0 (ms)
Writing Flag for Gy	Finished Writing
TRG Counter	3 (times)
Linked PreCrash Data Page No.	Page.1
Time from PreCrash TRG	4 (ms)
Deployment Time (B-Pillar)	Not Fired
Deployment Time (C-Pillar)	Not Fired
Deployment Side	Passenger's Side
Writing Flag for Side Crash	Finished Writing

Next Most Recent Pre-Crash Page.0 contained Occupant and Pre-Crash Data from a previous event not associated with the crash.

Frontal Crash Page.0 contained data indicating a non deployment event that was not associated with the crash. Side Crash Page.1 captured the system in its initial state and contained no data.

[8] Recorded at 200 ms

Interior Damage

The Scion sustained moderate interior damage resulting from impact forces, intrusion, occupant loading, and occupant contacts. The windshield was fractured and out of place, and the left front, left rear, and right front side glass was disintegrated. The occupant compartment was reduced by vertical intrusion of the windshield header and the roof, by longitudinal intrusion of the toe pan, instrument panel (IP), and steering column, and by lateral intrusion of the front left door panel and left roof side rail. The instrument panel were fractured and displaced in the left, center, and right sectors due to impact forces and intrusion. The front right door panel trim was fractured by impact forces. The driver's safety belt components and the steering column showed scuff marks from occupant contact.

Manual Restraint System

The Scion'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 non-adjustable D-ring anchorages and the center position safety belt was configured with a roof-mounted anchor. The second row safety belts were equipped with switchable ELR/ALR retractors.

Figure 6. Driver's safety belt showing load marks, 2010 Scion xD

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 vehicle's EDR report indicated the retractor pretensioner actuated during the crash at the time of the frontal air bag deployment. At the time of the vehicle inspection the retractor was functional and not locked. The D-ring, latch plate (**Figure 6**), and webbing showed scuff marks from occupant loading, and the stop button was displaced from the webbing at 55.0 cm (21.6 in) above the lower anchorage. Scuff marks and stretch marks on the webbing measuring 59.0 cm (23.2 in) in length began 50.0 cm (19.7 in) above the lower anchorage and extended upward,; a blood deposit measuring 14.0 cm (5.5 in) in length began 105.0 cm (41.3 in) above the lower anchorage and extended upward, and another scuff mark measuring 30.0 cm (11.8 in) began 159.0 cm (62.6 in) above the lower anchorage and extended upward to the D-ring. Based on the vehicle inspection, the front left safety belt was used to restrain the driver during the crash.

Supplemental Restraint System

The Scion's Supplemental Restraint System (SRS) included an air bag control module (ACM), driver and passenger frontal air bags, seat-mounted side impact air bags, side impact IC air bags, and safety belt retractor pretensioners for the first row. The vehicle was equipped with a Certified Advanced 208-Compliant (CAC) restraint system. 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 included dual-stage frontal air bags for the driver and front right passenger positions, safety belt buckle switch sensors, seat track positioning sensors, safety belt pretensioners, and a front right occupant weight-recognition sensor with an automatic air bag switch.

Figure 7. Driver's deployed frontal air bag, 2010 Scion xD

The Scion's advanced dual-stage frontal air bags were designed to deploy in two stages according to impact severity. Based on the EDR, the left frontal air bag deployed and the left front pretensioner actuated during the first event at 7 ms. The frontal air bag deployed at the "Low"[9] or first stage only. It was circular and measured 55.0 cm (21.7 in) in diameter in its post-inflated state. The air bag was configured with two internal tethers and two vent ports. It was not damaged but did show blood deposited by the driver in the lower quadrants (**Figure 7**).

Rollover

The Scion had a Static Stability Factor (SSF) of 1.27[10] and a four-star rollover rating, indicating the vehicle had a 10-20 percent chance of rollover[11]. 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 EBD distributed appropriate braking force between the front and rear wheels according to driving conditions. The Scion's tires were in good condition and their tread depth measured 6 mm (8/32 in).

After the vehicle-to-vehicle impact the Scion initiated a counterclockwise rotation and its front left tire engaged the roadway as evidenced by rim damage. The vehicle then initiated a left side leading trip rollover and rolled two quarter-turns. It came to rest on its roof and facing northwest in the southbound lane. Based on scene evidence the roll distance was 21.0 m (69.0 ft). At the time of the vehicle inspection[12] the tires were under-inflated 35-49 kPa (5-7 psi) per tire below the recommended pressure. An under- inflated tire deforms sooner under load than a properly inflated tire and this dynamic possibly increased the chance of rollover. Additionally, steering and braking input was lost by the driver following the first impact. The post-impact control loss, rotational and lateral forces, and rim engagement with the roadway contributed to the rollover.

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[9] Toyota ROT terminology

[10] Source: safercar.gov

[11] Source: www.edmunds.com

[12] The vehicle was inspected 58 days after the crash date.

2010 SCION xD OCCUPANT

Driver Demographics

Age/Sex:	21 years/Male
Height:	170 cm (67 in)
Weight:	68 kg (150 lb)
Eyewear:	Prescription eyeglasses
Seat type:	Bucket with adjustable head restraint
Seat track position:	Between middle and full-rear track
Manual restraint usage:	Lap and shoulder safety belt used
Usage source:	Vehicle inspection
Air bags:	Frontal air bag deployed, side impact IC air bag and seat-mounted side impact air bag not deployed
Alcohol, drug involvement:	None
Egress from vehicle:	Exited vehicle through front row left side window
Transport from scene:	Transported from scene by ground ambulance
Type of medical treatment:	Admitted to hospital for treatment, discharged after three days

Driver Injuries

Inj. No.	Injury	AIS 05/08	Injury Source	Confidence Level
1	Abrasions, abdomen, lower left quadrant	510202.1,2	Lap safety belt	Certain
2	Abrasions, hip, left	810202.1,2	Lap safety belt	Certain
3	Laceration, minor (9.0 cm), left lower leg	810602.1,2	Brake control pedal	Probable
4	Laceration, minor (2.0 cm), right lower leg	810602.1,1	Brake control pedal	Probable
5	Contusion, right lung, lower anterior	441407.2,1	Shoulder safety belt	Certain
6	Fracture, transverse process, L5	650220.2,6	Lap safety belt	Possible
7	Fracture, open, tibia, shaft, left, Grade II	854262.3,2	Brake control pedal	Probable
8	Fracture, open, fibula, left	854472.2,2	Brake control pedal	Probable

Source: Driver's medical records

Driver Kinematics

The 21-year-old male driver of the Scion was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt. The driver's seat was adjusted between the middle and full-rear

track position, the seat back was reclined slightly, and the adjustable head restraint was positioned 5.0 cm (2.0 in) above the seat back. Based on the driver interview, his hands were on the steering wheel at approximately 10 and 2 o'clock, and his left foot was resting on the floor pan. The driver was initiating a left turn in the intersection and the vehicle was traveling at an EDR-reported speed of 29.9 km/h (18.6 mph) at -200 ms to TGR. Based on the EDR report and the interview, he was accelerating and not braking at impact.

At impact with the Toyota, the driver's frontal air bag deployed and his safety belt retractor pretensioner actuated. The driver was displaced forward and right in response to the 1 o'clock direction of force and he loaded the safety belt. The safety belt components revealed load marks and the occupant sustained abrasions to the left abdomen and hip, and a contusion to the right lung. He sustained an L5 transverse process fracture caused by impact forces. The driver's left and right lower legs contacted the brake pedal and he sustained open fractures of the left tibia and fibula and minor lacerations to the left and right lower legs. The rubber pad was displaced from the brake pedal by occupant contact. Additionally, the driver's left and right knees impacted the steering column depositing scuff marks below the steering wheel.

The vehicle then initiated a counterclockwise rotation followed by a left side leading trip rollover that included two quarter-turns. During the first quarter-turn the driver was displaced to the left in response to the roll direction and was held in place in his seat by the pretensioned safety belt. His left torso and leg possibly loaded the interior front left door panel depositing scuff marks in the forward upper quadrant and fracturing the forward lower quadrant. During the second quarter-turn, the driver was displaced toward the roof and was suspended upside down in his seat by the safety belt when the vehicle came to final rest. After the vehicle came to rest, the driver deposited blood on the safety belt webbing, frontal air bag, steering wheel rim, and roof header. The driver self extricated and was transported to a local hospital.

2010 TOYOTA PRIUS

Description

The 2010 Toyota Prius was a four-door hatchback identified by the Vehicle Identification Number (VIN): JTDKN3DU4A0xxxxxx and its date of manufacture was May 2010. The odometer reading was unknown due to the inoperable electronic odometer. Standard equipment for this vehicle included a 1.8-liter, 4-cylinder engine, electric motor, continuously variable transmission, sealed nickel-metal hydride (NiMH) propulsion battery, front wheel drive, and 4-wheel anti-lock braking system (ABS). The NiMH battery was concealed aft of the rear bench seat and was protected by and aluminum cover and a removable carpeted panel. The battery pack was not damaged during the crash.

The vehicle manufacturer recommended P195/65R15 tires for the front and rear and tire pressure of 241 kPa (35 psi) for the front and rear. The vehicle was equipped with Goodyear Assurance tires of the recommended size that were manufactured in April 2010 and they were mounted to original equipment five-spoke aluminum rims. The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	7 mm (9/32 in)	Yes	Sidewall holed, tire de-beaded
LR	207 kPa (30 psi)	7 mm (9/32 in)	No	None
RR	214 kPa (31 psi)	7 mm (9/32 in)	No	None
RF	Tire flat	7 mm (9/32 in)	Yes	Tire de-beaded

Exterior Damage

The Toyota sustained direct and induced damage to the front end and induced damage to the left, right, and top planes. The left front tire was displaced rearward by 21.0 cm (8.3 in) and was restricted. The right front tire was displaced rearward by 25.0 cm (9.8 in) and was restricted. The front bumper fascia and bumper backing bar were displaced from the vehicle. The direct damage to the front end was distributed from bumper corner to bumper corner and measured 156.0 cm (61.4 in). The Field L measured 90.0 cm (35.0 in). Six crush measurements were taken at bumper level (**Figure 8**) as follows: C_1 = 45.0 cm (17.7 in), C_2 = 38.0 cm (15.0 in), C_3 = 44.0 cm (17.3 in), C_4 = 50.0 cm (19.7 in), C_5 = 58.0 cm (22.8 in), C_6 = 60.0 cm (23.6 in). Maximum crush was located at C6. The CDC for Event 1 was 12FDEW4. Based on the CDC for the Toyota in Event 1, the damage severity was severe.

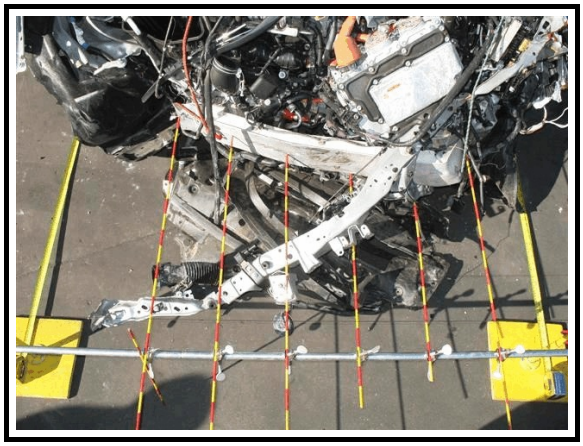

Figure 8. Front end crush measurement, 2010 Toyota Prius

Event Data Recorder

The Toyota's EDR was imaged during the vehicle inspection by connecting the Toyota EDR ROT directly to the EDR module number 89170-47080. The EDR was configured to capture pre-crash data, two frontal events, and two side events. It was not configured to capture rollover events. The recorded data was imaged and reported using software Version 1.4.1.1. The EDR data was summarized as follows:

Latest Pre-Crash Page.1	
Record Status	Recorded
System Information	
Page No. Of Latest PreCrash Data	Page.0
Time From Previous PreCrash TRG Event	16381 (ms)
Freeze Signal	Freeze

AB Deployment Flag	FrontalAB&Pretensioner
Diagnostic	
Writing Flag for Diag	Finished Writing
Occupant	
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	UnBelted
Occupant Detection	Unoccupied
Seat Position	RW
Shift Position	Others
PAB Manual Cut Off (N/A)	(N/A)
Writing Flag for PreCrash/Occupant	Finished Writing

PreCrash Data						
	-5	-4	-3	-2	-1	0
Speed	74.6	75.8	75.8	75.8	75.8	75.8 (mph)
Brake	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator	2.30 FULL	2.30 FULL	2.30 FULL	2.07 MIDDLE	0.78 OFF	0.78 OFF
Engine	4000	4000	4000	3600	2400	2000 (rpm)
Time from Last PreCrash Data: 300 (ms)						

Next Most Recent Pre-Crash Page.1 captured the system in its initial state and contained no data.

Frontal Crash Page.0	
Record Status	Recorded
Max delta Vx	32.0 (mph) recorded at 200 ms
Writing Flag for Gx	Finished Writing
TRG Counter	1 (times)
Previous Event	No Event
Linked PreCrash Data Page No.	Page.0

Time from PreCrash TRG	0 (ms)
Frontal AB Deployment Time	4 (ms)
Pretensioner Deployment Time	4 (ms)
Deployment Stage Driver	High
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

Frontal Crash Page.1, Side Crash Page.0, and Side Crash Page.1 captured the system in its initial state and contained no data.

SCENE DIAGRAM