On-Site Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS10005
2008 Toyota FJ Cruiser
Arizona
February 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 on-site investigation focused on the rollover dynamics of a 2008 Toyota FJ Cruiser involved in a two-vehicle crash and subsequent rollover. The crash occurred on a two-lane north/south roadway in February 2010 in the state of Arizona. The subject vehicle traveling southbound and was being driven by a restrained 42-year-old male. The other vehicle was a 1995 Ford Mustang that was traveling northbound and was being driven by a 53-year-old female. The Toyota crossed the centerline, entered the northbound lane, and the front end of the Toyota impacted the front end of the Ford in an offset frontal configuration. Following the vehicle-to-vehicle impact, the Toyota initiated a right side leading three quarter-turn trip rollover and came to rest on its left side in the southbound lane. The Toyota was equipped with frontal air bags, seat-mounted side air bags, and side impact inflatable curtain (IC) air bags; during the crash, the left frontal air bag, left seat-mounted side air bag and left IC air bag deployed. The driver of the Toyota sustained minor injuries related to post-crash activities and refused treatment at the scene. The driver of the Ford sustained incapacitating injuries and was transported to a local hospital. A 63-year-old female front right occupant in the Ford sustained non-incapacitating injuries and her level of treatment was not known. Both vehicles were towed due to damage and later declared total losses by their respective insurance companies. A complete inspection was conducted for the Toyota and a partial inspection was conducted for the Ford.

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TABLE OF CONTENTS

Background

The on-site investigation focused on the rollover dynamics of a 2008 Toyota FJ Cruiser (**Figure 1**) involved in a two-vehicle crash and subsequent rollover. The crash occurred on a two-lane north/south roadway in February 2010 in the state of Arizona. The subject vehicle traveling southbound and was being driven by a restrained 42-year-old male. The other vehicle was a 1995 Ford Mustang that was traveling northbound and was being driven by a 53-year-old female.

Figure 1. Subject vehicle, 2008 Toyota FJ Cruiser

The Toyota crossed the centerline, entered the northbound lane, and the front end of the Toyota impacted the front end of the Ford in an offset frontal configuration. Following the vehicle-to-vehicle impact, the Toyota initiated a right side leading three quarter-turn trip rollover and came to rest on its left side in the southbound lane. The Toyota was equipped with frontal air bags, seat-mounted side air bags, and side impact inflatable curtain (IC) air bags; during the crash, the left frontal air bag, left seat-mounted side air bag and left IC air bag deployed.

The driver of the Toyota sustained minor injuries related to post-crash activities and refused treatment at the scene. The driver of the Ford sustained incapacitating injuries and was transported to a local hospital. A 63-year-old female front right occupant in the Ford sustained non-incapacitating injuries and her level of treatment was not known. Both vehicles were towed due to damage and later declared total losses by their respective insurance companies. A complete inspection was conducted for the Toyota and a partial inspection was conducted for the Ford.

This on-site rollover investigation was identified by the National Highway Traffic Safety Administration (NHTSA) during a review of General Estimates System (GES) police reports. On February 19, 2010, DSI was sent the police report and instructed to locate the subject vehicle and obtain cooperation. Permission to inspect the subject vehicle was obtained and the case was assigned on February 24, 2010. Permission to inspect the other vehicle was obtained by the auction facility and the vehicle inspections were conducted on February 25, 2010. Permission was obtained to remove the Toyota's Event Data Recorder (EDR) and it was removed during the vehicle inspection. The EDR was then sent to the NHTSA for the purpose of imaging the EDR data. The NHTSA forwarded the Readout Tool (ROT) file to DSI and it was reported using software version 1.4.1.1. A summary of the EDR data is incorporated in this report.

Summary

Crash Site

The crash occurred on a north/south two-lane undivided roadway (**Figure 2**) consisting of two lanes measuring 3.6 m (11.8 ft) in width that were straight, level, and composed of asphalt. The travel lanes were delineated by a dashed yellow stripe in the center and solid white fog lines at the paved asphalt shoulders. The east shoulder measured 2.8 m (9.2 ft) and the west shoulder measured 3.3 m (10.8 ft) in width. The posted speed limit at this location was 80 km/h (50 mph). At the time of the crash conditions were dark, clear and dry.

Figure 2. Crash site, southbound approach of subject vehicle, 2008 Toyota FJ Cruiser

Pre-Crash

The Toyota was traveling southbound at a police-estimated speed of 63 - 80 km/h (40 - 50 mph); the vehicle's EDR report did not include Pre-crash data for speed, brake, accelerator, or engine status. The Toyota entered the northbound lane, returned to the southbound lane, then overcorrected to the left and reentered the northbound lane. Based on the interview, the driver of the Toyota was sleepy and was probably asleep moments before the crash. The Ford was traveling northbound at a police-estimated speed of 63 - 80 km/h (40 - 50 mph) and remained in its original travel lane to the point of impact.

Crash

The crash sequence included two events. The left front end of the Toyota impacted the left front end of the Ford in an offset frontal impact (Event 1). The Toyota's left frontal air bag, seat-mounted side air bag, and IC air bag deployed at impact. Following the initial impact, the Toyota overturned three quarter-turns (Event 2) and came to rest on its left side in the southbound lane. The Ford came to rest on the east shoulder.

Scene evidence deposited by both vehicles included gouge and scrape marks and fluid spills on the northbound and southbound lanes and on the east shoulder. The point of impact (POI) for Event 1 was identified by a scrape mark located 1.1 m (3.6 ft) east of the center line in the northbound lane. The Toyota's left front wheel and tire were displaced from the axle and the vehicle rotated counterclockwise to approximately 90 degrees from its at-impact heading angle. The vehicles right side tires and rims engaged the roadway with sufficient opposing lateral force to induce a trip rollover. At the trip point, the Toyota's right front rim deposited a gouge mark on the roadway measuring 1.0 m (3.3 ft) and located on the center line. Additionally, the right side tires and rims revealed scuff marks consistent with roadway contact.

During the second quarter-turn the Toyota rolled onto its roof and its roof rack depositing a 29.0 cm

(11.4 in) gouge mark in the southbound lane at 73.0 cm (28.7 in) west of the center line. The vehicle rolled onto its left side and deposited parallel gouge marks 15.0 cm (5.9 in) apart and measuring 27.0 cm (10.6 in) and 24.0 cm (9.5 in) in length, respectively; and another gouge mark measuring 50.0 cm (19.7 in) in length. The Toyota then came to rest with its rear end in the northbound lane and its front end in the east shoulder. A fluid spill measuring 2.0 cm (6.6 ft) in diameter identified the vehicle's at-rest location. During the rollover, the vehicle's roof rack was displaced from the vehicle.

The Ford sustained damage to the front left axle and the rim and tire were displaced from the vehicle. It initiated a post-impact counterclockwise rotation and the vehicle's undercarriage deposited a patch of four gouge and scrape marks in the roadway on its path to final rest. The marks measured 2.0 m (6.6 ft), 1.2 m (3.9 ft), 1.4 m (4.6 ft), and 4.9 m (16.0 ft) in length, respectively, and were distributed over a distance of 18.5 m (60.7 ft) from the center line to the east edge of the east shoulder. The police report stated the Ford continued its post-impact trajectory for approximately 152.4 m (500.0 ft). Based on scene evidence, it was determined the Ford departed the roadway on the right side and came to rest off the roadway.

For the Toyota in Event 1, the Standard algorithm of WinSMASH calculated a Total Delta-V of 16.0 km/h (9.9 mph); the longitudinal and lateral components were -15.8 km/h (-9.8 mph) and -2.8 km/h (-1.7 mph), respectively. The Toyota's EDR reported a maximum longitudinal Delta-V of 27.5 km/h (17.1 mph). Based on National Accident Sampling Systems (NASS) coding conventions a reconstruction for corner type impacts are considered borderline.

For the Ford in Event 1, WinSMASH calculated a Total Delta-V of 26.0 km/h (16.2 mph); the longitudinal and lateral components were -24.4 km/h (-15.2 mph) and 8.9 km/h (5.5 mph), respectively. The reconstruction is considered borderline due to the corner type impact.

Post-Crash

The driver of the Toyota unbuckled his safety belt and exited the vehicle under his own power. During the interview, he stated he did not remember through which opening he exited. The driver of the Toyota walked north to the at-rest location of the Ford and attempted to open its left side door, which was jammed shut.

Extrication efforts to remove the driver of the Ford from her vehicle continued for 1½ hours post-crash. The left front door was removed from the vehicle, the driver was removed due to serious injuries and she was transported to a local hospital. The police report stated the passenger of the Ford sustained a left arm contusion; her transport status and level of treatment were not determined. Both vehicles were towed due to damage and were later sold to private parties.

Vehicle Data - 2008 Toyota FJ Cruiser

The Toyota was identified by the Vehicle Identification Number (VIN): JTEBU11F68Kxxxxxx and its date of manufacture was December 2007. Based on auction facility photos the odometer reading was 68,410 km (42,509 mi). The vehicle was equipped with a 4.0-liter, 6-cylinder engine, automatic transmission, 4-wheel drive, electric power steering with tilt column functionality, and tire pressure

monitoring system. The braking and suspension included an Anti-lock Braking System (ABS), Vehicle Stability Control (VSC), Traction Control, Electronic Brake-force Distribution (EBD), and Brake Assist intended to mitigate the chance of rollover.

The vehicle manufacturer recommended P265/70R17 tires for the front and rear with a recommended cold pressure of 221 kPa (32 psi) for the front and rear. The Toyota was equipped with BIG O S/T Big Foot P265/70R17 tires in the recommended size that were manufactured in the thirty-first week of 2009. The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	8 mm (10/32 in)	No	De-beaded, sidewall cut
LR	200 kPa (29 psi)	8 mm (10/32 in)	No	None
RR	221 kPa (32 psi)	8 mm (10/32 in)	No	None
RF	207 kPa (30 psi)	9 mm (11/32 in)	No	None

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

Vehicle Damage - 2008 Toyota FJ Cruiser

Exterior Damage

The Toyota sustained direct and induced damage to the front end, left side and undercarriage during the vehicle-to-vehicle impact (Event 1), and left side, right side, and roof during the rollover (Event 2). The left front wheel and tire, 40.0 cm (15.7 in) of the left front bumper fascia, and the roof rack were displaced from the vehicle. For Event 1, direct damage to the front end began at the front left bumper corner and extended 40.0 cm (15.8 in) to the right. The Field L was distributed from bumper corner to bumper corner and measured 132.0 cm (52.0 in) (**Figure 3**). Direct damage down the vehicle's left side began at the left front bumper corner, extended rearward 130.0 cm (51.2 in), and ended at the left A-pillar. Six crush measurements were taken at bumper level as follows: C_1 = 11.0 cm (7.9 in), C_2 = 3.0 cm (1.2 in), C_3 = 3.0 cm (1.2 in), C_4 = 2.0 cm (0.8 in), C_5 = 4.0 cm (1.6 in), C_6 = 2.0 cm (0.8 in). Maximum crush was located at C_1 and the Collision Deformation Classification (CDC) was 12FLEE4.

Figure 3. Subject vehicle, front end crush profile measurement

For the rollover, direct damage to the right side consisted of gouges to the rims and scuff marks to the tires resulting from contact with the roadway. Direct damage to the roof was distributed longitudinally beginning at the windshield header, extending rearward 247.0 cm (97.2 in), and ending at the backlight header. Direct damage to the roof was distributed laterally between the roof side rails and measured 121.0 cm (47.6 in). Additionally, the roof rack sustained direct damage to all sides during the rollover. Direct damage to the vehicle's left side began at the left rear bumper corner, extended forward 342.0 cm (134.6 in), and ended at the left front bumper corner. The direct damage was distributed vertically from the sill to the roof side rail and measured 137.0 cm (53.9 in). Maximum vertical roof crush measured 6.0 cm (2.4 in) and was located at 35.0 cm (13.8 in) aft of the windshield header and 10.0 cm (3.9 in) inboard of the left roof side rail (**Figure 4)**. Maximum lateral crush to the left roof side rail measured 5.0 cm (2.0 in) and was located above the A-pillar. The CDC for Event 2 was 00TZDO2.

Figure 4. Subject vehicle, maximum vertical roof crush measurement

Interior Damage - 2008 Toyota FJ Cruiser

The Toyota sustained interior damage resulting from impact damage, intrusion and occupant loading. The windshield was fractured and in place, and the left front side glass was disintegrated resulting in integrity loss. The passenger compartment was reduced in area due to lateral intrusion of the left A-pillar and roof side rail, longitudinal intrusion of the instrument panel, and vertical intrusion of the roof. The vehicle's greenhouse sustained moderate intrusion during the rollover. Maximum vertical intrusion to the left roof measured 12.0 cm (4.7 in). Maximum lateral intrusion to the left roof side rail measured 2.0 cm (0.8 in).

The driver's safety belt components were scuffed due to occupant loading. The driver's frontal air bag, left seat-mounted side air bag, and left IC air bag exhibited scuff marks or transfers resulting occupant loading. Additionally, the visor located above the left roof side rail was bent suggesting occupant loading during the rollover.

The Toyota's steering column was loose and yielded play of 6.0 cm (2.4 in) vertically, 2.0 cm (0.8 in) laterally, and 3.0 cm (1.2 in) longitudinally.

Manual Restraints - 2008 Toyota FJ Cruiser

The Toyota'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 was equipped with a switchable ELR/Automatic Locking Retractor (ALR).

The driver's adjustable D-ring anchorage was in the full-up position and the latch plate was scratched indicating historical usage. The safety belt retractor pretensioner actuated during the crash and the webbing was in the unspooled position. The D-ring showed a scuff mark measuring 1.0 x 5.0 cm (0.4 x 2.0 in) and a transfer from the webbing measuring 1.0 x 1.0 cm (0.4 x 0.4 in). The latch plate showed scuff marks on both sides where the webbing passed through it (**Figure 5**). The safety belt webbing had six scuff or stretch marks. A stretch mark measuring 4.0 cm (1.6 in) was located 21.0 cm (8.3 in) below the stop button; a scuff mark measuring 5.0 x 7.0 cm (2.0 x 2.8 in) was located 28.0 cm (11.0 in) above the stop button and resulted from loading at the latch plate; a 2.0 x 2.0 cm (0.8 x 0.8 in) scuff mark was located 74.0 cm (29.1 in) above the stop button; a 5.0 x 12.0 cm (2.0 x 4.7 in) scuff mark was located 100.0 cm (39.4 in) above the stop button; another scuff mark measuring 5.0 x 12.0 cm (2.0 x 4.7 in) was located 110.0 cm (43.3 in) above the stop button and resulted from loading at the D-ring; and a 5.0 x 8.0 cm (2.0 x 3.1 in) scuff mark was located 139.0 cm (54.7 in) above the stop button. Based on the vehicle inspection it was determined that the safety belt was used to restrain the driver during the crash.

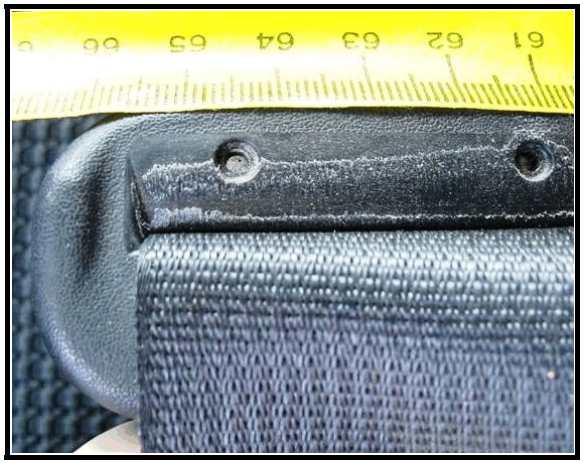

Figure 5. Driver's safety belt latch plate showing scuff marks

Supplemental Restraint System - 2008 Toyota FJ Cruiser

The vehicle's Supplemental Restraint System (SRS) included an Event Data Recorder (EDR), driver and passenger frontal air bags, seat-mounted side air bags, IC air bags, and safety belt retractor pretensioners for the front row. During the interview the driver stated that the vehicle had been in no previous crashes involving air bag deployments, the air bags were original to the vehicle, and they had not been recalled, replaced or serviced.

The Ford 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. The vehicle's advanced dual-stage frontal air bags were designed to deploy according to impact severity. The vehicle-to-vehicle impact resulted in sufficient longitudinal deceleration to signal deployment of the driver's frontal air bag and safety belt pretensioner. Additionally, the left B-pillar side impact sensor triggered the deployment of the left seat-mounted side air bag and left IC air bag.

The frontal air bag deployed from the steering wheel hub through module cover flaps that opened at their tear points and were not damaged. Based on the EDR report's Frontal Crash Page 0, the "Time form Pre-Crash TGR"[1] was 0 milliseconds (ms) and the "Frontal AB[2] Deployment Time" and "Pretensioner Deployment Time" were 16 ms. Additionally, "Deployment Stage Driver" indicated "High" for the CAC dual-stage frontal air bag. The air bag measured 60.0 cm (23.6 in) in diameter and was configured with two internal tethers and two vent ports. It showed two scuff marks near the center of the front panel resulting from occupant loading (**Figure 6**). One scuff mark measured 2.0 cm (0.8 in) in length and was located 3.0 cm (1.2 in) from the center of the bag in the upper right quadrant. Another scuff mark measured 2.0 x 2.0 cm (0.8 x 0.8 in) and was located 4.0 cm (1.6 in) from the center of the bag in the lower right quadrant.

Figure 6. Frontal air bag showing location of occupant loading

Figure 7. Left seat-mounted side air bag showing location of skin oil transfer

The left seat-mounted side air bag deployed from the outboard aspect of the driver's seat back. Based on the EDR report's Side Crash Page 0, the "Time form Pre-Crash TGR" was 5 ms and the "Deployment Time (B-Pillar)" was 26 ms. The air bag was semicircular in shape, measured 34.0 cm (13.4 in) in width and 40.0 cm (15.7 in) in height. The inboard panel of the air bag showed a skin oil transfer (**Figure 7**) measuring 11.0 x 15.0 cm (4.3 x 5.9 in) that was deposited by the driver's left forearm during the crash. The outboard panel of the air bag showed scuff marks measuring 5.0 x 15.0 cm (2.0 x 5.9 in) and 2.0 x 2.0 cm (0.8 x 0.8 in) resulting from contact with the door panel when the seat-mounted side air bag was loaded by the driver.

The left IC air bag deployed from the roof side rail over the front and second rows. Based on the EDR report's Side Crash Page 0, the "TGR Counter" indicated "2 (times)" assumed to mean the left IC air bag deployed at the same time as the left seat-mounted side air bag. The IC air bag was rectangular in shape and measured 195.0 cm (76.8 in) in length and 60.0 cm (23.6 in) in height. The front row sector of the inboard panel showed fabric and skin oil transfers measuring 1.0 x 1.0 cm (0.4 x 0.4 in) each. The fabric transfer was located 75.0 cm (29.5 in) aft of the leading edge and 8.0

[1] Assumed to indicate Trigger

[2] Assumed to indicate Air Bag

cm (3.1 in) above the bottom edge and the skin oil transfer was located 57.0 cm (22.4 in) aft of the leading edge and 25.0 cm (9.8 in) above the bottom edge. The fabric transfer was deposited by the driver's left shoulder and the skin oil transfer was deposited by the driver's left hand.

Event Data Recorder - 2008 Toyota FJ Cruiser

The Toyota's EDR was configured to capture up to two frontal and two side impact events. It was configured to capture limited pre-crash data and did not record rollover events. The EDR recorded two events including one Frontal Crash and one Side Crash, based on the frontal and side locations of the sensors which triggered the air bag deployments and pretensioner actuation. For the Frontal Crash, the EDR recorded 200 msec of Post-Crash Velocity Change Data; for the Side Crash, 96 msec of Post-Crash Velocity Change Data was recorded. The recorded data was summarized in the following tables.

Latest Pre-Crash Page 0	
System Information	
Page No. of Latest Pre-Crash Data	Page 0
Time from Previous Pre-Crash TRG Event	16381 ms
Freeze Signal	Freeze
AB Deployment Flag	Frontal AB & Pretensioner
Diagnostic Information	
Ignition Cycle	0 (times)
Lamp on Term	0 (times)
Occupant Data	
Belt Switch Status Driver	Belted
Belt Switch Status Passenger	Unbelted
Occupant Detection	Unoccupied
Seat Position	RW[3]
Shift Position	(N/A)
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

[3] Assumed to indicate Rearward

Next Most Recent Pre-Crash Page 1[4]	
Occupant Data	
Belt Switch Status Driver	Unbelted
Belt Switch Status Passenger	Unbelted
Occupant Detection	Unoccupied
Seat Position	FW[5]
Shift Position	(N/A)
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
Deployment Stage Driver	Not Fired
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

Frontal Crash Page 0	
Max delta-Vx	17.1 (mph)
TGR Counter	1 (times)
Previous Event	No Event
Linked Pre-Crash Date Page No.	Page 0
Time from Pre-Crash to TGR	0 ms
Frontal AB Deployment Time	16 ms
Pretensioner Deployment Time	16 ms
Deployment Stage Driver	High
Deployment Stage Passenger	Not Fired
Writing Flag for Frontal Crash	Finished Writing

[4] Next Most Recent Pre-Crash Page 1 refers to a prior event and was not associated with this crash

[5] Assumed to indicate Forward

Side Crash Page 0	
Time form TRG to Initial G	0 ms
TGR Counter	2 (times)
Previous Event	Frontal
Linked Pre-Crash Date Page No.	Page 0
Time from Pre-Crash TGR	5 ms
Deployment Time (B-Pillar)	26 ms
Deployment Time (C-Pillar)	Not Fired
Deployment Side	Driver's side
Writing Flag for Frontal Crash	Finished Writing

Rollover - 2008 Toyota FJ Cruiser

The Toyota had a Static Stability Factor (SSF) rating of 1.10. 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 had a rollover resistance rating of 3 out of 5 stars and had a 26 percent chance of rollover. The vehicle's ABS incorporates four sensors to prevent the wheels from locking under hard braking; VSC detects front and rear wheel slide during cornering and adjusts engine torque and braking force for individual wheels; active Traction Control reduces tire slippage during wet conditions; and EBD distributes appropriate braking force between the front and rear wheels according to driving conditions.[6] The Toyota's tires were in good condition, had a minimum tread depth of 8 mm (10/32 in), and the inflated tires' measured pressure was at or near the manufacturer's recommended cold pressure. The road surface consisted of dry asphalt and it was in good condition.

At impact with the Ford, the Toyota initiated a counterclockwise rotation that continued until the vehicle's right side tires and rims engaged the roadway with sufficient opposing lateral force to initiate a right side leading trip rollover. Except for the right side tires and rims, the vehicle's right side plane did not contact with the roadway. The Toyota rolled onto its roof displacing the roof rack from the vehicle. Vertical roof crush was probably mitigated by the presence of the roof rack during the second quarter-turn. The vehicle then rolled onto its left side, slid on the roadway for a short distance, and came to rest in the northbound lane and the east shoulder. The vehicle deposited gouges in the roadway along its post-impact travel path over a distance of 14.3 m (46.9 ft). Based on scene evidence, the vehicle's estimated roll distance was 13.0 m (42.7 ft).

Due to the absence of braking input by the driver of the Toyota, its stability and traction control technologies were not engaged. Additionally, engagement with the other vehicle, displacement of

[6] Toyota USA Newsroom, Toyota FJ Cruiser Gains Significant Safety Features For 2008.

the left front tire, post-impact rotation, and undercarriage contact with the roadway combined to further destabilize the vehicle resulting in the rollover.

Vehicle Data - 1995 Ford Mustang

The Ford was identified by the Vehicle Identification Number (VIN): 1FALP4040SFxxxxxx, the date of manufacture was January 1995, and the odometer reading was 13,024 (8,093 m). The vehicle was equipped with a 3.8-liter, 6-cylinder engine, automatic transmission, and rear-wheel drive. The vehicle manufacturer's recommended tire size was P205/55R15 and the recommended cold tire pressure was not known. The vehicle was equipped with Falken ZIEX ZE512 P225/60R15 tires that were manufactured in 2008. The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	5 mm (6/32 in)	No	Sidewall and tread cut
LR	186 kPa (27 psi)	5 mm (6/32 in)	No	None
RR	193 kPa (28 psi)	5 mm (6/32 in)	No	None
RF	193 kPa (28 psi)	6 mm (8/32 in)	Yes	None

Exterior Damage - 1995 Ford Mustang

The Ford sustained direct and induced damage to the front end and left side, and induced damage to the right side and roof. The front left tire sustained cuts to the sidewall and tread and was displaced from the rim. The front bumper fascia was displaced from the vehicle and the left side wheelbase was reduced by 57.0 cm (22.4 in). Additionally, the left side door was removed during post-crash extrication activity.

Figure 8. Front end crush profile measurement

Direct damage to the front end began at the left bumper corner and extended 30.0 cm (11.8 in) to the right resulting in a narrow corner impact. The Field L was distributed from bumper corner to bumper corner and measured 120.0 cm (47.2 in) (**Figure 8**). Crush down the left side extended from the left front bumper corner to the B-pillar and measured 342.0 cm (134.6 in). Six crush measurements were taken at bumper level as follows: C_1 = 43.0 cm (16.9 in), C_2 = 25.0 cm (3.9 in), C_3 = 21.0 cm (8.3 in), C_4 = 13.0 cm (5.1 in), C_5 = 1.0 cm (0.4 in), C_6 = 0 cm and maximum crush was located at C_1. For the Ford, the CDC for Event 1 was 11FLEE6.

Occupant Demographics - 2008 Toyota FJ Cruiser

Driver

Age/Sex:	42 years/Male
Height:	185 cm (73 in)
Weight:	102 kg (225 lb)
Seat type:	Bucket with adjustable head restraint
Seat track position:	Rear-most
Manual restraint usage:	Lap and shoulder belt
Usage source:	Vehicle inspection
Air bags:	Frontal air bag, seat-mounted side air bag, and IC air bag deployed
Alcohol, drug involvement:	None
Type of medical treatment:	None

Occupant Kinematics - 2008 Toyota FJ Cruiser

Driver

The 42-year-old male driver was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt which was snug and properly positioned. He was steering the vehicle with his right hand only, his right foot was on the accelerator and his left foot was on the floor. The driver's seat cushion was set to the rear-track position and his seat back was slightly reclined. Conditions were dark, he was sleepy, and prior to impact he overcorrected his steering to the left, entered the northbound lane, and impacted the other vehicle.

At impact, the driver's safety belt pretensioner actuated and his frontal air bag, seat-mounted side air bag, and IC air bag deployed. The driver was displaced forward and slightly left in response to the direction of force. He loaded the safety belt and frontal air bag with his chest depositing scuff marks and stretch marks to the safety belt and scuff marks to the frontal air bag. The driver stated during the interview that, following the crash, his sternum and upper chest were sore for a few days; this condition resulted from loading of the safety belt webbing and the frontal air bag. His left forearm loaded the seat-mounted side air bag depositing a skin oil transfer and his left shoulder and hand loaded the IC air bag depositing a fabric transfer and a skin oil transfer.

The Toyota initiated a post-impact counterclockwise rotation and the driver was displaced to the right in response to the rotational forces. The vehicle then initiated a ride side leading trip rollover, further displacing the driver to the right. The vehicle rolled three quarter-turns and came to rest on

its left side. During the rollover, the driver remained secured in his seat by the pretensioned safety belt. He possibly loaded the left sun visor with an upper extremity deforming the visor.

He unbuckled his safety belt and exited the vehicle under his own power. After exiting the vehicle he was not aware of any visible lacerations. While attempting to assist the occupants of the Ford he sustained a minor left hand laceration measuring approximately 7.6 cm (3.0 in) in length as well as other minor lacerations to his left forearm and right hand. Later he complained of pain to his sternum and chest, which he attributed to safety belt and frontal air bag loading. The driver refused on-scene medical treatment and did not seek treatment later or miss work due to injury. Based on the interview the driver did not sustain any codable injuries during the crash.

Attachment 1. Scene Diagram