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NHTSA

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Special Crash Investigations On-Site ET-2000 Guardrail End Terminal Investigation Vehicle: 2007 Toyota Camry Location: Missouri Crash Date: November 2015

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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. This report and associated case data are based on information available to the Special Crash Investigation team on the date the report was published.

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16. Abstract

This report covers an on-site investigation of a passenger vehicle impact to an ET-2000 guardrail end terminal that is of interest to the Federal Highway Administration (FHWA). This crash occurred on the west roadside of a four-lane, divided U.S. highway. The Toyota was a four-door sedan equipped with multi-stage frontal air bags, driver's knee air bag, front seat-mounted side impact air bags, and side impact Inflatable Curtain (IC) air bags. A restrained 20-year-old female driver occupied the vehicle. The Toyota was traveling south in a right curve in the left lane when the left side wheels departed the roadway. The driver initiated a right steering maneuver and the vehicle rotated clockwise across the roadway. The vehicle then departed the right (west) side of the roadway and the left plane impacted the ET-2000 end terminal of a blocked-out W-beam guardrail (event 1). The impact damaged and displaced the guardrail and resulted in deployment of the driver's seat-mounted side impact air bag and the left Inflatable Curtain (IC) air bag. The vehicle rotated counterclockwise as the guardrail deformed and then rolled over, right side leading, an estimated 13 quarter turns down a ravine. The driver sustained police-reported "C" (possible) injuries and was airlifted to a trauma center where she was hospitalized for 12 days for treatment of serious injuries. The Toyota was towed from the crash scene due to damage.

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TABLE OF CONTENTS

INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER

ON-SITE ET-2000 GUARDRAIL END TREATMENT INVESTIGATION

CASE NUMBER - IN15030
LOCATION - MISSOURI
VEHICLE - 2007 TOYOTA CAMRY
CRASH DATE - November 2015

BACKGROUND

This report covers an on-site investigation of a passenger vehicle impact to an ET-2000 guardrail end terminal (**Figure 1**) that is of interest to the Federal Highway Administration (FHWA). This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted photographs of the vehicle and the damaged guardrail end terminal to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration (NHTSA) in November 2015, and assigned to the Special Crash Investigations team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2007 Toyota Camry (**Figure 2**). The crash occurred in November 2015 at 1700 hours, in Missouri and was investigated by a local police agency. The vehicle, guardrail, and crash scene were inspected in November 2015.

Figure 1: The damaged guardrail and ET-2000

Figure 2: The damaged 2007 Toyota Camry

This crash occurred on the west roadside of a four-lane, divided U.S. highway. The Toyota was a four-door sedan equipped with multi-stage frontal air bags, driver's knee air bag, front seat-mounted side impact air bags, and side impact Inflatable Curtain (IC) air bags. A restrained 20-year-old female driver occupied the vehicle. The Toyota was traveling south in a right curve in the left lane when the left side wheels departed the roadway. The driver initiated a right steering maneuver and the vehicle rotated clockwise across the roadway. The vehicle then departed the right (west) side of the roadway and the left plane impacted the ET-2000 end terminal of a blocked-out W-beam guardrail (event 1). The impact damaged and displaced the guardrail and resulted in deployment of the driver's seat-mounted side impact air bag and the left Inflatable Curtain (IC) air bag. The vehicle rotated counterclockwise as the guardrail deformed and then rolled over, right side leading, an estimated 13 quarter turns down a ravine. The driver sustained

police-reported “C” (possible) injuries and was airlifted to a trauma center where she was hospitalized for 12 days for treatment of serious injuries. The Toyota was towed from the crash scene due to damage.

CRASH SUMMARY

Crash Site: This crash occurred at dusk on the west roadside of a curved, four-lane, divided U.S. highway. The weather conditions were clear with 16.1 kilometers (10 miles) visibility, calm winds, a temperature of 12.8 °C (55 °F), and a dew point of -0.6 °C (31 °F), according to local weather reports. The highway had two bituminous southbound through lanes that were curved to the right and separated from the two northbound through lanes by a grass median. The design radius of curvature of the southbound lanes at the median edge line was 281.1 m (921.9 ft) based on data provided by MoDOT. The superelevation of the southbound lanes was 8 percent and the roadway grade in the area of the Toyota’s approach to the west roadside departure was negative 3 percent. The southbound travel lanes were each 3.6 m (11.8 ft) wide and were bordered by a 1.7 m (5.6 ft) wide bituminous median shoulder and a 2.9 m (9.5 ft) wide bituminous outside shoulder. A rumble strip was located on the edge line of each shoulder. A blocked out-W-beam guardrail equipped with an ET-2000 end terminal was located on the west side of the southbound lanes and adjacent to an approximately 8 m (25 ft) deep ravine. The speed limit was 105 km/h (65 mph). The Crash Diagram is included on pages 11 and 12 of this report.

Pre-Crash: The Toyota was traveling south in a right curve in the left lane (**Figure 3**). The driver was reported in her medical records as stating that she fell asleep. The vehicle’s left side tires departed the travel lane and encountered the rumble strip on the edge line and median shoulder. The driver initiated a right steering maneuver and the vehicle began to yaw clockwise. A yaw mark from the left front tire that began on the yellow median edge line and extended into and across the left lane was observed and documented at the SCI crash scene inspection. A speed-to-side slip calculation (Attachment A) based on the radius of curvature of this yaw mark was performed and yielded a vehicle speed of approximately 153 km/h (95 mph)[1] at the onset of the yaw mark. The left front yaw mark extended across the left lane for 48.1 m (157.8 ft) where a yaw mark from the left rear tire was observed in the left lane, near the centerline. The vehicle continued to yaw clockwise across the roadway an additional 26.9 m (88.2 ft) and departed the outside edge of the west shoulder approximately 3 m (10 ft) prior to the end of the guardrail (**Figure 4**).

Figure 3: Southbound approach of the Toyota

[1] The Toyota’s Event Data Recorder had a an upper limit for pre-crash speed reporting of 121 km/h (75.8 mph). The EDR reported this limit from -4.6 to -0.6 sec prior to establishment of the recording trigger.

Crash: The left front door of the Toyota (**Figure 5**) impacted the ET-2000 (**Figure 6**, event 1). The calculated speed at impact (Attachment A) was 92 km/h (57 mph). The EDR-reported speed at trigger was 104 km/h (64.6 mph). The accuracy of this value is not known since the vehicle was in a yaw and the driver was applying the brakes prior to trigger. At the moment of impact, the left side of the vehicle was oriented approximately 90 degrees to the end terminal. The angle of the approach path of the vehicle's Center of Mass (COM) relative to the end terminal was approximately 20 degrees. The force direction on the Toyota was within the 11 o'clock sector based on the travel path of the COM relative to the guardrail. The impact resulted in deployment of the driver's seat- mounted side impact air bag and the left IC air bag. The Event Data Recorder (EDR)-reported the maximum Delta Vs occurring at the air bag control module sensor, B-pillar sensor, and C- pillar sensor as 19.8 km/h (12.3 mph), 20.1 km/h (12.5 mph), and 23.4 km/h (14.6 mph), respectively. The Toyota rotated counterclockwise as it remained engaged with the guardrail following impact and traveled approximately 12 m (39 ft) as the guardrail was deformed and displaced in a southwesterly direction. The vehicle then rolled over (event 2), right side leading, an estimated 13 quarter turns across a distance of 45 m (147.6 ft), coming to final rest near the bottom of the ravine on its left plane heading west. The "Rollover Initiation" type was classified as "Climb Over."

Post-Crash: Emergency responders cut and removed the windshield then removed the driver from the vehicle. The extrication from the vehicle took one hour according to her medical records. She was airlifted to a trauma center and hospitalized for 12 days for treatment of serious injuries. The driver's blood alcohol concentration (BAC) was reported in her medical records as .142. The vehicle was towed from the crash scene due to damage.

Figure 4: View southwest to approach of the Toyota to impact with the guardrail

Figure 5: Damage to the left front door and sill of the Toyota from the impact with the ET-2000

Figure 6: The damaged ET-2000, tape measure in feet and tenths of feet and centimeters

END TERMINAL AND GUARDRAIL DAMAGE

The left plane impact of the Toyota to the ET-2000 extruded 1.09 m (3.6 ft) of guardrail (**Figure 7**) toward the field side of the guardrail. Posts 1-4 were fractured and separated from the guardrail (**Figures 8** and **9**), while post 5 was slightly displaced within the ground (**Figure 10**) and the blockout was slightly displaced and damaged. The blockout for post 6 was slightly damaged and displaced, and the post slightly displaced (**Figure 11**) within the post hole. A 9.1 m (30.0 ft) length of guardrail was damaged by the impact. There were three kinks in the damaged guardrail downstream of the ET-2000 and one within the ET-2000. The kink within the ET-2000 (**Figure 12**) impacted the vehicle's left rear door (**Figures 13**) as the guardrail deformed, crushing the door and penetrating 23 cm (9.1in) into the second row (**Figure 13**) and contacting the back of the driver's seat. The extruded section of guardrail impacted and deformed the front portion of the left front door (**Figure 5**). The FHWA Guardrail Form is attached to the end of this report as Attachment B.

Figure 7: Extruded guardrail from the ET-2000; arrows shows red paint from contact the Toyota's left front door

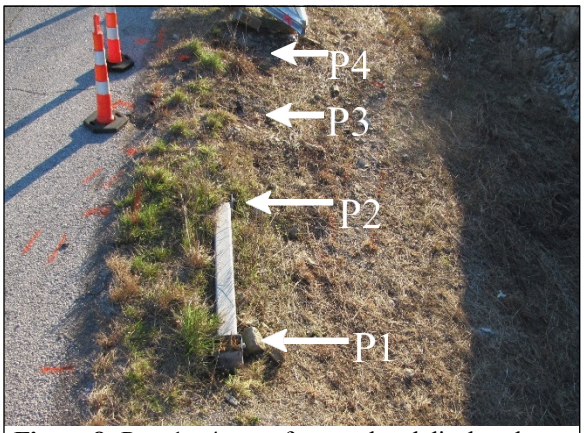


Figure 8: Post 1 - 4 were fractured and displaced, view southwest

Figure 9: Damaged post 4, view west to field side,

Figure 10: Slightly displaced post 5, view east

2007 TOYOTA CAMRY

DESCRIPTION

2007 Toyota Camry: The Toyota was a front wheel drive, five-occupant, four-door sedan (VIN: 4T1BE46K87Uxxxxxx) that was manufactured in February 2007. The vehicle was equipped with a 2.4-liter I-4 engine, automatic transmission, four-wheel anti-lock brakes with electronic brake force distribution and brake assist. The vehicle was also equipped with multi-stage frontal air bags, driver's knee air bag, front seat-mounted side impact air bags, side impact IC air bags, and a tilt/telescoping steering column. The tilt and telescoping adjustment could not be determined at the SCI vehicle inspection since the column was displaced and locked by damage to the instrument panel from intrusion of the left front door. The specified wheelbase was 278 cm (109.4 in).

The vehicle manufacturer's recommended tire size was P215/60R16. The vehicle was equipped with Capital Sport UHP tires size P225/55R17 on the left front, right front and right rear. The left rear wheel was displaced off the vehicle during the rollover and was not at the vehicle inspection. The manufacturer's recommended cold tire pressure for the front and rear tires was 207 kPa (30 psi). The tire data for the Toyota are presented in the table on the following page.

Figure 11: Block-out of post 6 slightly damaged

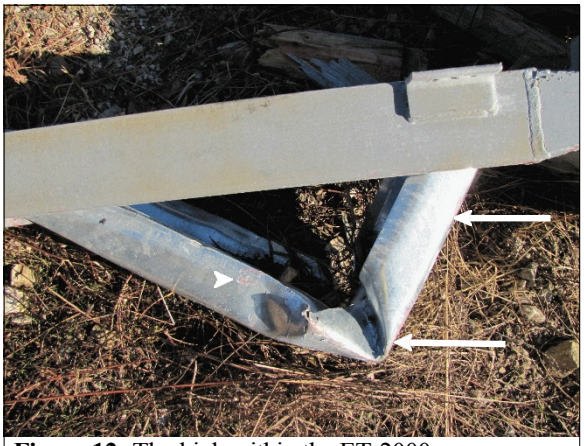


Figure 12: The kink within the ET-2000; arrows show red paint from contact with Toyota's left rear door

Figure 13: Hole in left rear door from contact by guardrail kink

Position	*Measured Pressure*	*Measured Tread Depth*	*Restricted*	*Damage*
LF	172 kPa (25 psi)	4 mm (5/32 in)	Yes	None
LR	Unknown	Unknown	Unknown	Unknown
RR	193 kPa (28 psi)	5 mm (6/32 in)	Yes	None
RF	193 kPa (28 psi)	4 mm (5/32 in)	No	None

The front row was equipped with driver and front right occupant cloth-covered bucket seats with adjustable head restraints. The second row was equipped with a cloth-covered split bench seat with folding backs and adjustable head restraints. The driver's seat track was adjusted between the forward and middle positions and the seat back was slightly reclined. The remaining seats were unoccupied at the time of the crash.

EXTERIOR DAMAGE

Exterior Damage Events 1: The Toyota sustained direct damage to both left side doors and the quarter panel from the impact with the guardrail. There was also overlapping damage on the left rear door and quarter panel from ground contact during the rollover. The direct damage from the initial contact with the ET-2000 began[2] 84 cm (33.1 in) rear of the left front axle. The shape of the extruder head was stamped into the door sheet metal and the contact also involved the sill. Direct damage from contact by the extruded guardrail also occurred at the front of the door beginning at the seam between the door and the fender. The direct damage from contact by a kinked section of guardrail began on the left rear door at the left B-pillar. The maximum crush to the left front door from the ET-2000 contact was approximately 24 cm (9.4 in). The maximum crush to the left rear door from contact by a kinked section of the guardrail was approximately 49 cm (19.3 in). The crush values are approximate since the door sheet metal was displaced off the doors. The kink penetrated through the door and contacted the driver's seat back. The extent of penetration into the second row was 23 cm (9.1 in).

Damage Classification Event 1: The Collision Deformation Classifications (CDC) was 11LZEW3 (340 degrees). The force direction was based on the path of the vehicle's COM as the vehicle approached impact with the guardrail. The severity of the damage was moderate.

Exterior Damage Event 2: The top plane, both end planes, and both side planes sustained direct damage during the rollover. The top plane sustained minor damage with primarily lateral and some diagonal scratches located on the hood. Minor scratching was also located on the right roof side rail and roof. There was also damage to the roof that appeared to be related to work by emergency responders. Emergency responders also cut both A-pillar with a hydraulic rescue tool and cut and removed the windshield. The most severe damage during the rollover occurred to the left quarter panel, left portion of the back plane, and right portion of the front plane. Grass and dirt were deposited in these areas and the left rear corner of the vehicle was displaced vertically 40 cm (15.7 in), while the right portion of the front plane was crushed rearward and

[2] The locator measurement is approximate since the door sheet metal was displaced off the vehicle.

grass and dirt we deposited in the damaged components. These damaged areas suggested that there was an end-over-end motion of the vehicle occurring at some point during the rollover. The maximum vertical and lateral crush to the roof structure was 5 cm (2.0 in) and 3 cm (1.2 in), respectively, occurring at the left back light header and right C-pillar, respectively.

Damage Classification Event 2: The CDC was 00LZAO3. The severity of the damage was moderate.

EVENT DATA RECORDER

The Toyota's EDR was imaged with version 16.2.1 of the Bosch Crash Data Retrieval software and reported with version 17.7.1 The vehicle was without an ignition key and the fuse block was not accessible due to damage, so the data was imaged via direct connection to the Air Bag Control Module (ACM). The EDR report is attached at the end of this report as Attachment C.

The EDR was capable of storing deployment or non-deployment events for front, rear, or side crash types. The EDR did not record rollover data. A deployment event will be recorded when an air bag or pretensioner actuates. A deployment event cannot be overwritten by a subsequent event. A non-deployment event will be recorded if an air bag did not deploy or a pretensioner did not actuate. A non-deployment event could be overwritten by a succeeding deployment event.

The EDR recorded two "Front/Rear" and two "Side" events. These events were identified as the "Most Recent Event," "1st Prior Event," 2nd Prior Event," and "3rd Prior Event." The "1st Prior Event," 2nd Prior Event," and "3rd Prior Event" were non-deployment events and the timing data reported in the "Event Record Summary at Retrieval" report suggested they were not related to this crash. The "Most Recent Event" was reported as a deployment event to the driver's side suggesting it was recorded during the impact with the guardrail.

Most Recent Event: The recording status was reported as "Complete" and Diagnostic Trouble Codes (DTC) 51 and 53[3] were reported. The ignition cycles since the DTCs were set were recorded as 1,217. The "Air Bag Warning Lamp On Time Since DTC Was Set" was reported as 28,020 minutes. The driver's seat belt buckle switch was reported as "Buckled" and the driver's seat position was reported as "Rearward" of the switch point. The EDR reported 4.6 sec of pre-crash data. The EDR data limitations stated that the upper limit for vehicle pre-crash speed recording was 122 km/h (75.8 mph). The EDR reported this limit from -4.6 to -0.6 sec, suggesting that the vehicle's travel speed exceeded this value since the brake switch was reported as on from -3.6 to -0.6 sec. The EDR-reported vehicle speed at 0 sec (trigger) was 104 km/h (64.6 mph). The brake switch was reported as "Off" at 0 sec. The EDR reported lateral Delta V at the sensors located at the B-pillar, C-pillar, and ACM. The maximum lateral Delta V at each sensor was reported as 20.1 km/h (12.5 mph), 23.4 km/h (14.6 mph), and 19.9 km/h (12.3 mph), respectively.

[3] The EDR data limitations states that DTCs reported in the EDR report are related to the air bag system. According to the service manager at a Toyota dealership, DTC 51 and 53 were related to electrical shorts in the driver side squib.

INTERIOR DAMAGE

The interior of the Toyota sustained moderate intrusion from the impact with the guardrail and the rollover. The most severe intrusions into the driver's seating position involved the forward upper quadrant of the left front door and B-pillar, which intruded laterally 20 cm (7.9 in) and 14 cm (5.5 in), respectively. A kink in the guardrail that was located within the chute 73 cm (28.7 in) rear of the extruder head penetrated through the left rear door and intruded 23 cm (9.1 in) into the left rear seating position and contacted the back of the driver's seat.

The forward lower quadrant of the left front door was scuffed from contact by the driver's left knee. Occupant contact also likely occurred to the rear portion of the intruded door; however, the upper portion of the plastic door panel was missing and the deformation and discoloration of the lower panel adjacent to the deployed seat-mounted side impact air bag could have resulted from contact by the occupant's left hip loading through the air bag, deformation of the plastic related to the door intrusion, or both.

Both left side doors and the right rear door were jammed shut. The right front door remained closed an operational. All of the non-fixed glazing was closed at the time of the crash. The left front, left rear, and second left rear glazing was disintegrated by impact forces. The windshield was probably cracked by impact forces. It had been cut and removed by emergency responders. The right front glazing was also fractured by emergency responders, and both A-pillars had been cut with a hydraulic rescue tool. The right rear and second right rear glazing was undamaged.

MANUAL RESTRAINT SYSTEMS

The front and second row seating positions were equipped with three-point lap and shoulder seat belts with sliding latch plates. The front row seat belts had adjustable upper anchors and the driver's upper anchor was adjusted to the full-down position. The front row seat belts were also equipped with retractor-mounted pretensioners. The driver's seat belt retractor was locked but it could not be determined if it was due to pretensioner actuation or damage to the B- pillar. The vehicle's EDR did not report the status of the driver's pretensioner.

The driver was restrained by the lap and shoulder seat belt. The belt had been cut by emergency responders and the length of the belt webbing extending from the locked retractor was consistent with usage. The vehicle's EDR reported the driver's "Buckle Switch" status as "Buckled."

SUPPLEMENTAL RESTRAINT SYSTEMS

The Toyota was equipped with multi-stage frontal air bags, driver's knee air bag, front seat-mounted side impact air bags, and side impact IC air bags. The left IC air bag and driver's seat-mounted side impact air bag deployed during the impact with the guardrail.

The IC air bags were located along the roof side rails behind the headliner and the deflated left IC air bag extended from the A-pillar to the C-pillar. The front portion of the IC had been cut by emergency responders. The remaining portion of the IC was undamaged and unremarkable.

The driver's seat mounted side impact air bag was located in the outboard side of the driver's seat and deployed through a tear seam. The tear seam separated and the deployed air bag was found between the intruded B-pillar and seat back, suggesting the air bag was either put in this position during the extrication of the driver, or it had been impinged by the intruded B-pillar during deployment.

2007 TOYOTA CAMRY OCCUPANT

DRIVER DEMOGRAPHICS

Age/Sex:	20 years/Female
Height:	163 cm (64 in)
Weight:	52 kg (115 lbs)
Eyewear:	Unknown
Seat Type:	Bucket
Seat Track Position:	Between forward and middle
Manual Restraint Usage:	Lap and shoulder seat belt
Usage Source:	Vehicle inspection, EDR
Air Bags:	Seat-mounted side impact and left IC air bags, deployed; frontal and knee air bags, not deployed
Alcohol/Drug Involvement:	BAC = .142
Egress from Vehicle:	Removed by emergency responders
Transport from Scene:	Airlifted to trauma center
Medical Treatment:	Hospitalized

DRIVER INJURIES

Injury No.	Injury	AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Pelvic ring fracture, incomplete disruption of posterior arch, including displaced fracture left superior pubic ramus, fracture left inferior pubic ramus, mild diastasis of left sacro-iliac joint, and comminuted fracture left sacral ala; ORIF[4] required	856161.3	Left front door panel, rear lower quadrant	Certain
2	Fracture midshaft left clavicle with distal fragment displaced 75% in a caudal direction; ORIF[1] required	750651.2	Torso portion of seat belt system	Certain
3	Laceration (rupture), 4 cm (1.6 in) in length, full thickness (with perforation) at dome of urinary bladder	540625.3	Left front door panel, rear lower quadrant	Probable

[4] ORIF = Open reduction and internal fixation

Injury No.	Injury	AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
4	Laceration, 2 cm (0.8 in) with perforation small bowel with contamination of small bowel contents within abdomen	541424.3	Tandem IPC configuration Air bag, driver's side impact Left front door panel, rear lower quadrant Lap portion of seat belt system	 Possible Probable Probable
5	Laceration (serosal tear) without perforation, 5 cm (2.0 in) longitudinally of distal sigmoid colon	540822.2	Lap portion of seat belt system	Probable
6	Laceration (serosal tear) without perforation, 3 cm (1.2 in), upper rectum, not further specified	543622.2	Left front door panel, rear lower quadrant	Probable
7	Contusion (ecchymosis) overlying left shoulder, not further specified	710402.1	Torso portion of seat belt system	Certain
8 9 10 11	Abrasion and bruise[5] to bilateral inner thighs	810202.1 810202.1 810402.1 810402.1	Occupant's left and right medial thighs	Probable
12	Contusion (ecchymosis) lateral left knee, not further specified	810402.1	Left front door panel, forward lower quadrant	Certain

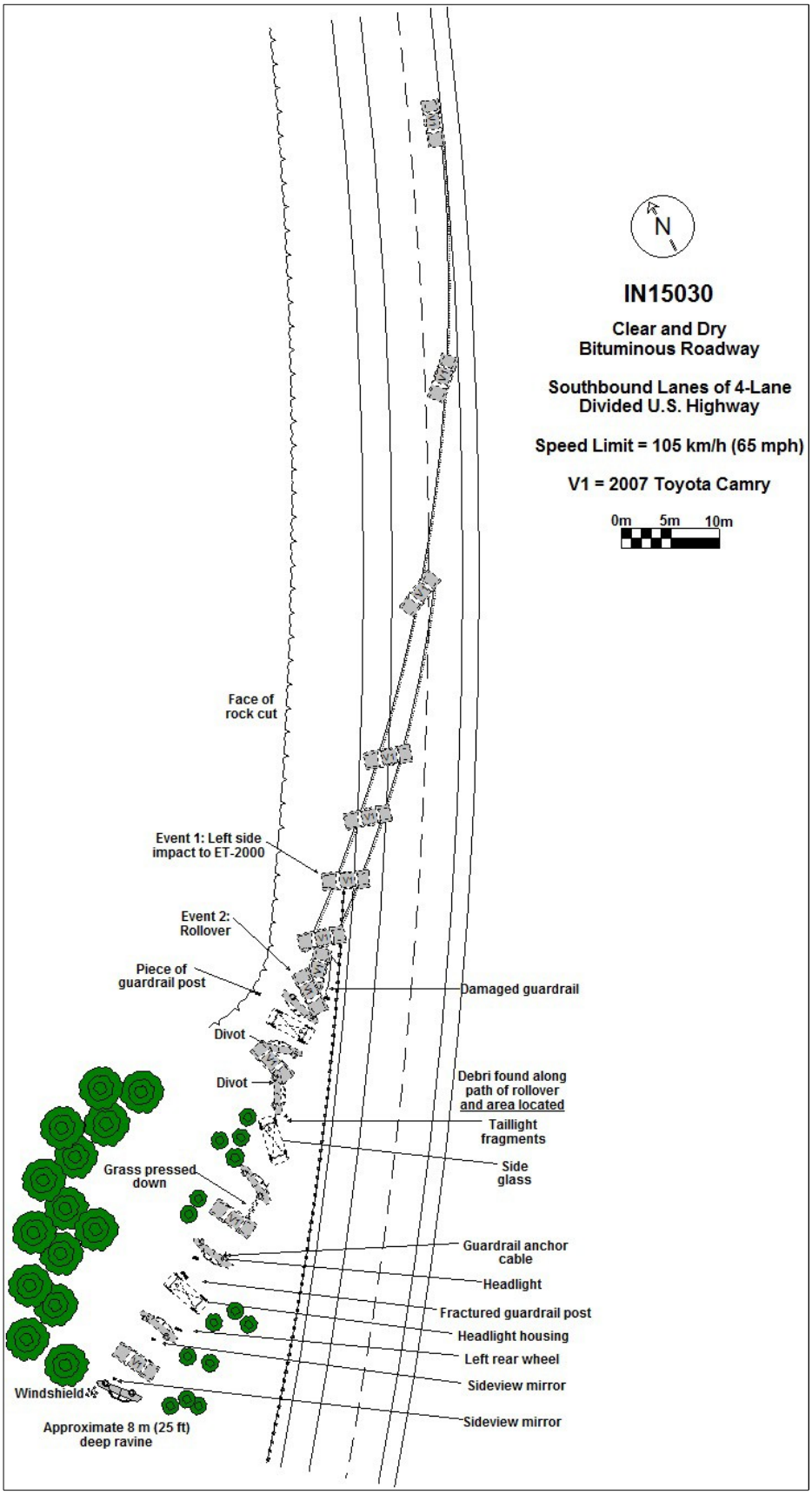
*Sources: Emergency Room Records, Hospitalization Records, and EMS treatment Record. Injury Numbers 8 and 9 came only from **Emergency Room Records**. Injury Numbers 4 through 7 and 10 came only from **Hospitalization Records**. Injury Numbers 1 through 3 came from a combination of **Emergency Room** and **Hospitalization Records**.*

DRIVER KINEMATICS

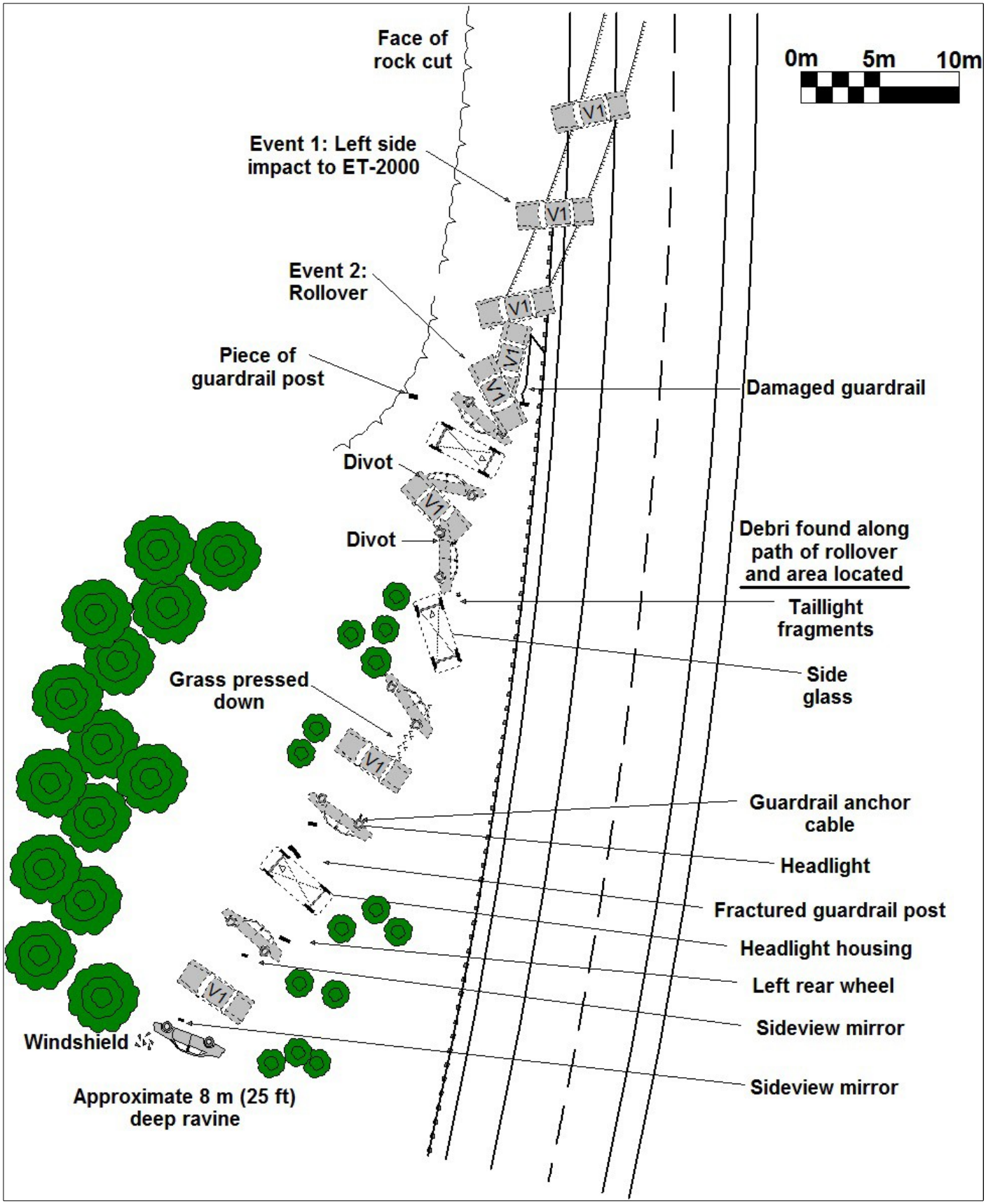
The driver was restrained by the lap and shoulder seat belt. The seat track was adjusted between the forward and middle positions and the seat back was slightly reclined. The driver was displaced to the left within her seat belt as the Toyota rotated clockwise across the roadway and decelerated. The left plane impact to the ET-2000 resulted in deployment of the left IC air bag and the driver's seat-mounted side impact air bag. The left side of the driver's body contacted the intruded left front door. She sustained a pelvic ring fracture and lacerations of the urinary bladder and upper rectum from contact with the rear lower quadrant of the left front door. Contact to the forward lower quadrant of the door resulted in a contusion to the left knee. The inside of the driver's thighs contacted each other causing an abrasion and contusion to each thigh. The driver also sustained a fractured left clavicle, contusion to the left shoulder, and lacerations to the small bowel and distal sigmoid colon from loading the seat belt. The driver was then redirected in multiple directions within the seat belt as the vehicle rolled over, right side leading, 13 quarter turns. The vehicle came to final rest on its left plane and emergency responders cut and removed the windshield and removed the driver from the vehicle. Her medical records stated the extraction from the vehicle took 1 hour. She was airlifted to a trauma center and hospitalized for 12 days.

[5] Bruises described as dark purple and yellow.

CRASH DIAGRAM



Crash Diagram, Detail View



Appendix A
Speed Reconstruction

Speed Reconstruction

Speed to Sideslip:

The speed of a vehicle at the onset of a yaw can be calculated from the following data:

1. The cross grade (superelevation) in the direction of slippage: **e**
2. The coefficient of friction of the roadway: **f**
3. The radius of the path of the vehicle's Center of Mass (COM) at yaw initiation: **R**

Values of **e** and **f** were provided by a Missouri Department of Transportation engineer (MoDOT) from roadway plan and roadway friction test data.

e = 0.08
f = 0.845

The **R** of the vehicle's COM at the initiation of the yaw can be calculated from a chord (**C**) and middle ordinate measurement (**M**) of the left front tire yaw mark. **R** is then adjusted by half the vehicle's track width to obtain the **R** of the path of COM (**RCOM**). The **C** and **M** measurements were taken directly from the yaw mark at the scene by an MoDOT engineer:

C = 60 ft (18.3 m)
M = 0.69 ft (0.21 m)

R = $C^2/8M + M/2$ = 652.5 ft (198.9 m)

R adjusted for half the vehicle's track width for RCOM:

RCOM = 652.5 - 2.6 = 649.9 ft (198.1 m)

Speed at onset of yaw:

$$S = 3.86\sqrt{RCOM(f+e)}$$
$$S = 3.86\sqrt{649.9(0.845+0.08)}$$
$$S = 94.5 \text{ (152.1 km/h)}$$

Speed at impact with ET-2000:

The speed at impact with the ET-2000 was calculated by applying a drag factor to the vehicle as it traveled from onset of the yaw to impact. The EDR reported pre-crash braking from -3.6 sec to -0.6 sec prior to algorithm enable; however the extent of braking is not known. A range of drag factors were considered based on the coefficient of friction of the roadway and the possible extent of braking across the yaw and average drag factor of 0.75 was considered to be reasonable.

The variables:

Initial velocity (**Vi**) = 95 mph =139.3 ft/sec
End velocity (**Ve**) = velocity at impact with ET-2000
Acceleration (**a**) = Drag factor * g = -0.75 * 32.2 ft/sec
Distance in yaw to impact (**d**) = 256 ft

$$Ve = \sqrt{Vi^2 + 2ad}$$

$$Ve = \sqrt{139.3^2 + (2 \times 32.2 \times -0.75 \times 256)}$$

$$Ve = 83.9\,ft / \sec = 57.2 mph$$ (92.1 km/h)

Appendix B
In-Service End Treatment Evaluation
Data Collection Form

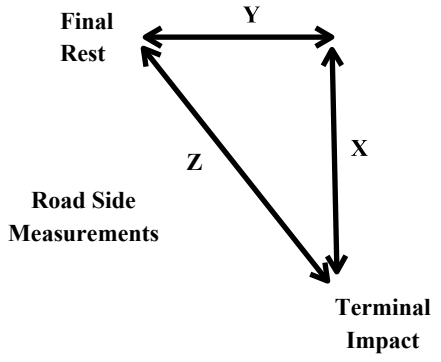
Case No.: IN15030

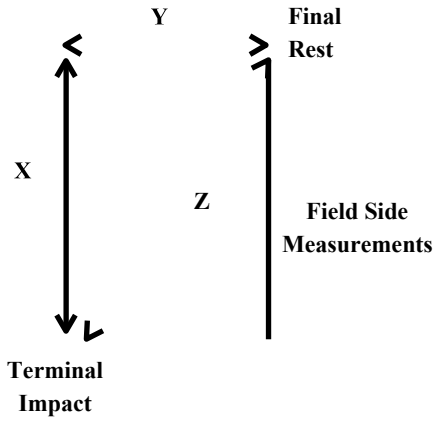
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	November 2015	**TIME OF CRASH (MILITARY)**	Evening
Case Number	IN15030	**State**	Missouri
Traffic Route	U.S. highway	**Direction (Southbound = SB)**	SB
Ambient Conditions (at time of crash)			
Temperature (°F)	55	**Lighting**	Dusk
Atmospheric	Clear & Dry		

SCENE INFORMATION	
Type of area where crash occurred	❒Urban ☒Rural ❒Suburban
Terminal on a horizontal curve?	❒No ❒Curve/LT ☒Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	57 mph (Reconstructed)
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 187ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 174 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 59 ft
Super elevation	☒+2% (+8%) ❒-2% ❒ NONE or FLAT
Curve Radius (ft.)	921.9 ft

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN15030

ON-SCENE INFORMATION		
End Treatment Type	☒Extruder	☒ET2000 ❒ET-PLUS 4in ❒ET-PLUS 5in ❒SKT ❒FLEAT ❒SOFT STOP
	❒Telescope	❒X-LITE ❒X-TENSION
Curb?	☒No ❒Yes	❒AASHTO Type A ❒AASHTO Type B ❒AASHTO Type C ❒AASHTO Type D ❒AASHTO Type E ❒AASHTO Type F ❒AASHTO Type G ❒AASHTO Type H
Curb Height:		

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
1	Wood	7.7 x 5.3	None		Unk		12.0		Unk
2	Wood	7.7 x 6.1	None		Unk		11.9		6 ft 3 in

Case No.: IN15030

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
3	Wood	7.7 x 5.9	Wood	7.4 x 5.9	Unk		12.1		6 ft 3 in
4	Wood	7.7 x 5.9	Wood	7.7 x 5.9	No		11.9		6 ft 3 in
5	Wood	7.7 x 6.1	Wood	8.1 x 6.1	No		12.6		6 ft 3 in
6	Wood	7.9 x 6.1	Wood	7.7 x 5.9	No		12.7		6 ft 1 in
7	Wood	7.7 x 5.9	Wood	7.7 x 5.9	No		12.6		6 ft 3 in
8	Steel	5.9 x 3.9	Wood	7.7 x 5.9	No		12.7		6 ft 3 in

Case No.: IN15030

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
9	Steel	5.9 x 4.0	Wood	7.7 x 5.9	No		12.7		6 ft 3 in
10									
11									
12									

Additional Comments

Case No.: IN15030

EXTRUDER			
Feeder Channel Width at impact head	❒4inches ☒5 inches ❒Other _____		
Guide Chute Exit Height (in.)	15.3 in		
Connection of feeder channels to head damaged?	☒No ❒Yes	Are Welds Broken?	☒No ❒Yes
Anchor Cable Present?	❒No ☒Yes	Connected?	☒No ❒Yes
Rail Extrusion?	❒No ☒Yes	Length (ft. in.)	3 ft 7 in
Rail Extrusion Direction	❒Traffic Side ☒Field Side		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	30ft		

TELESCOPE				
Rail Displacement	❒No	❒Yes; Length:	No of Panels Displaced	❒1 ❒2 ❒3 ❒4 ❒5 ❒6

ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	❒No	☒Yes ;	No. of Kinks in Rail: 4
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	❒No ☒Yes		
Did vehicle impact other objects after impact with terminal?	❒No ☒Yes		
Object Contacted	Ground (rollover)		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	24%	26%	22%
Adjacent Lane Width (ft)	11.8 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		
Shoulder Type	Bituminous		

Shoulder Width (ft)	9.5 ft
Guardrail Height (in)	26.4 in

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Passenger Vehicle	
Vehicle Identification Number (VIN)	4T1BE46K87Uxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3359 lbs (includes weight of driver)	
Vehicle orientation upon impact	❒Case Type 1 ☒ Case Type 2 ❒Case Type 3 ❒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 ❒ Case Type 7 ❒ Case Type 8 ❒ Other	
If 'Other', describe		
Collision Deformation Classification	11LZEW3	
Delta-V	12.3 Lateral (From EDR as ACM sensor, no longitudinal Delta V reported	
Occupant Compartment Penetration of rail	❒No	☒Yes ; Describe: Rail kink penetrated LR door 9 in and contacted back of driver's seat
Quarter Turns (NASS EDS variable: Rollover)	❒1 ❒2 ❒3 ❒4 ❒5 ❒6 ❒7 ❒8 ❒9 ❒10 ❒11 ❒12 ☒13 ❒14 ❒15 ❒16 ❒17+	
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	Guardrail Face (See page 3 of report)	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	Bounce Over (See page 3 of report)	

Appendix C
2007 Toyota Camry
Event Data Recorder (EDR) Report[1]

[1] The EDR Report contained in this technical report was imaged using the current version of the Bosch CDR software at the time of the investigation. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN/Frame Number	4T1BE46K87U******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	IN15030_V1_ACM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 16.2.1
Reported with CDR version	Crash Data Retrieval Tool 17.7.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Front/Rear (2), Side (2)

Comments

No comments entered.

Data Limitations

CDR Record Information:

- Due to limitations of the data recorded by the airbag ECU, such as the resolution, data range, sampling interval, time period of the recording, and the items recorded, the information provided by this data may not be sufficient to capture the entire crash.
- Pre-Crash data is recorded in discrete intervals. Due to different refresh rates within the vehicle's electronics, the data recorded may not be synchronous to each other.
- Airbag ECU data should be used in conjunction with other physical evidence obtained from the vehicle and the surrounding circumstances.
- If the airbags did not deploy or the pretensioners did not operate during an event that meets a specified recording threshold, it is called a Non-Deployment Event. Data from a Non-Deployment Event can be overwritten by a succeeding event that meets the specified recording threshold. If the airbag(s) deploy or the pretensioners are operated, it is called a Deployment Event. Deployment Event data cannot be overwritten or deleted by the airbag ECU following that event.
- If power supply to the airbag ECU is lost during an event, all or part of the data may not be recorded.
- "Diagnostic Trouble Codes" are information about faults when a recording trigger is established. Various diagnostic trouble codes could be set and recorded due to component or system damage during an accident.
- The airbag ECU records only diagnostic information related to the airbag system. It does not record diagnostic information related to other vehicle systems.
- The TaSCAN, Global Tech Stream, or Intelligent Tester II devices (or any other Toyota genuine diagnostic tool) can be used to obtain detailed information on the diagnostic trouble codes from the airbag system, as well as diagnostic information from other systems. However, in some cases, the diagnostic trouble codes of the airbag system recorded by the airbag ECU when the event occurred may not match the diagnostic trouble codes read out when the diagnostic tool is used.

General Information:

- The data recording specifications of Toyota's airbag ECUs are divided into the following categories. The specifications for 12EDR or later are designed to be compatible with NHTSA's 49CFR Part 563 rule.
  - 00EDR / 02EDR / 04EDR / 06EDR / 10EDR / 12EDR / 13EDR / 15EDR / 17EDR
- The airbag ECU records data for all or some of the following accident types: frontal crash, rear crash , side crash, and rollover events. Depending on the installed airbag ECU, data for side crash and/or rollover events may not be recorded.
- This airbag ECU records post-crash data, and depending on the airbag ECU, may record pre-crash data.
  - If a single event occurs independently, the data for that event is recorded on a one-to-one basis.
  - If multiple events occur successively (within a period of approximately 500ms), the establishment of the recording trigger for the first event is defined as the "pre-crash recording trigger". Pre-crash data for the first event and post-crash data for each successive event is then recorded.
- The airbag ECU has two recording pages (memory maps) to store pre-crash data. Additionally, to store post-crash data, the airbag ECU has two recording pages for each accident type: two pages for frontal and rear crash, two pages for a side crash, and two pages for rollover event.
- The data recorded by the airbag ECU includes correlating information between each previously occurring event (i.e., information that clarifies the collision event sequence. This correlation information consists of the following items.
  - Time from Previous Pre-Crash TRG
  - Linked Pre-Crash Page
  - Time from Pre-Crash TRG
  - TRG Count
  - Previous Crash Type
- The point in time at which the recording trigger is established is regarded as time zero for the recorded data.

- The recording trigger judgment threshold value differs depending on the collision type (i.e., frontal crash, rear crash, side crash, or rollover event).
- Time series data for side crash may have 24 or 25 sampling points.
- Some of the data recorded by the airbag ECU is transmitted to the airbag ECU from various vehicle control modules by the vehicle's Controller Area Network (CAN).
- In some cases, the airbag ECU part number printed on the ECU label may not match the airbag ECU part number that the CDR tool reports. The part number retrieved by the CDR tool should be considered as the official ECU part number.

Data Element Sign Convention:
The following table provides an explanation of the sign notation for data elements that may be included in this CDR report.

Data Element Name	Positive Sign Notation Indicates
Max. Longitudinal Delta-V	Forward
Longitudinal Delta-V	Forward
Max. Lateral Delta-V , B-Pillar Sensor	Outside to Inside
Max. Lateral Delta-V , C-Pillar Sensor	Outside to Inside
Max. Lateral Delta-V , Slide Door Sensor	Outside to Inside
Lateral Delta-V , B-Pillar Sensor	Outside to Inside
Lateral Delta-V , C-Pillar Sensor	Outside to Inside
Lateral Delta-V , Slide Door Sensor	Outside to Inside
Lateral Delta-V , Airbag ECU Sensor	Left to Right
Roll Angle Peak	Clockwise Rotation
Roll Angle	Clockwise Rotation
Lateral Acceleration , Airbag ECU Sensor *	Right to Left

* For sensing a rollover

Data Definitions:
1)
- The "ON" setting for the "Freeze Signal" indicates a state in which the non-volatile memory can not be overwritten or deleted by the airbag ECU. After "Freeze Signal" has been turned ON, subsequent events will not be recorded.
- "Recording Status" indicates a state in which all recorded event data has been written into the non-volatile memory, or a state in which this process was interrupted and not fully written into the non-volatile memory. If "Recording Status" is "Incomplete", recorded event data may not be valid.
- "Time to Deployment Command" indicates the time between recording trigger establishment and the determination of airbag deployment. This value may differ from the actual time it takes for the airbag to fully deploy.
- Even if an airbag/pretensioner did not deploy due to the "front passenger airbag disable switch and/or "RSCA Disable Switch" in the ON position or other disabling criteria are met, the "Time to deployment command" data element for that airbag/pretensioner may still be recorded.
- "Engine RPM" indicates the number of engine revolutions, not the number of motor revolutions. The recorded value has an upper limit of 5,200 rpm. Resolution is 400 rpm and the value is rounded down and recorded. For example, if the actual engine speed is 799 rpm, the recorded value will be 400 rpm.
- The upper limit for the recorded "Vehicle Speed" value is 122 km/h (75.8mph). Resolution is 2km/h (1.2mph) and the value is rounded down and recorded. The accuracy of the "Vehicle Speed" value can be affected by various factors. These include, but not limited, to the following.
  - Significant changes in the tire's rolling radius
  - Wheel lock and wheel slip
- "Accelerator Rate" value is recorded as a voltage. The voltage increases as the driver depresses the accelerator.
- The "Drive" setting for the "Shift Position" value indicates the shift position state is other than "R,"(Reverse), "N" (Neutral), or "P" (Park). If sequential shift had been used, "Invalid" may be displayed.
- Depending on the type of occupant sensor installed in the vehicle, one of the following three recording formats for "Occupancy Status, Passenger" will be utilized.
  - Occupied / Not Occupied
  - Adult / Child / Not Occupied
  - AM50 / AF05 / Child / Not Occupied
- Resolution of the "Air Bag Warning Lamp ON Time Since DTC was Set" is 15 minutes, and the value is rounded down and recorded.
- "Longitudinal Delta-V" indicates the change in forward speed after establishment of the recording trigger. This does not refer to vehicle speed, and it does not include the change in speed during the period from the start of the actual collision to establishment of the recording trigger.
- Depending on the specifications, "Roll Angle peak" can be recorded as absolute value.
- "Roll Angle peak" may not always match the peak value within the "Roll Angle" sampling points due to differences in data calculation method.
- For "Lateral Delta-V", the sensor location (B-pillar, front door, C-pillar, and slide door) shows the outline of a typical sensor position. Sensory location can be confirmed using the repair manual.
- "Time from Previous Pre-Crash TRG" indicates the time between the establishment of an event's pre-crash recording trigger to the establishment of a more recent event's pre-crash recording trigger. The upper limit for the recorded value is 16,381 milliseconds. In the event of establishment of the first pre-crash recording trigger after the ignition is switched ON, the upper limit value(max value) is recorded.
- "TRG Count" indicates a calculated value of the number of times recording triggers have been established for all crash types. The sequence in which each event occurred can be verified from the "TRG Count". The smaller the "TRG Count" value, the older the data. The upper limit for the recorded value is 65,533 times. When more than one event reaches the upper limit, the actual "TRG Count" may be greater than what is displayed for that event.
- "Linked Pre-Crash Page" is used to link 'paged" pre-crash data with 'paged" post-crash data. When old pre-crash data is overwritten by new pre-crash data, the "Linked Pre-Crash Page" value may record a page number that is not actually linked.
- Resolution of the "Time from Pre-Crash to TRG" is 100 [ms], and the value is rounded down and recorded.

05004_ToyotaDENSO_r026

System Status at Time of Retrieval

ECU Part Number	89170-33490
ECU Generation	04EDR
Recording Status, All Pages	Complete
Freeze Signal	ON
Freeze Signal Factor	Side Airbag, Driver Deployment
Diagnostic Trouble Codes Exist	Yes
Time from Previous Pre Crash TRG (msec)	16381 or greater
Latest Pre-Crash Page	1
Contains Unlinked Pre-Crash Data	No

Event Record Summary at Retrieval

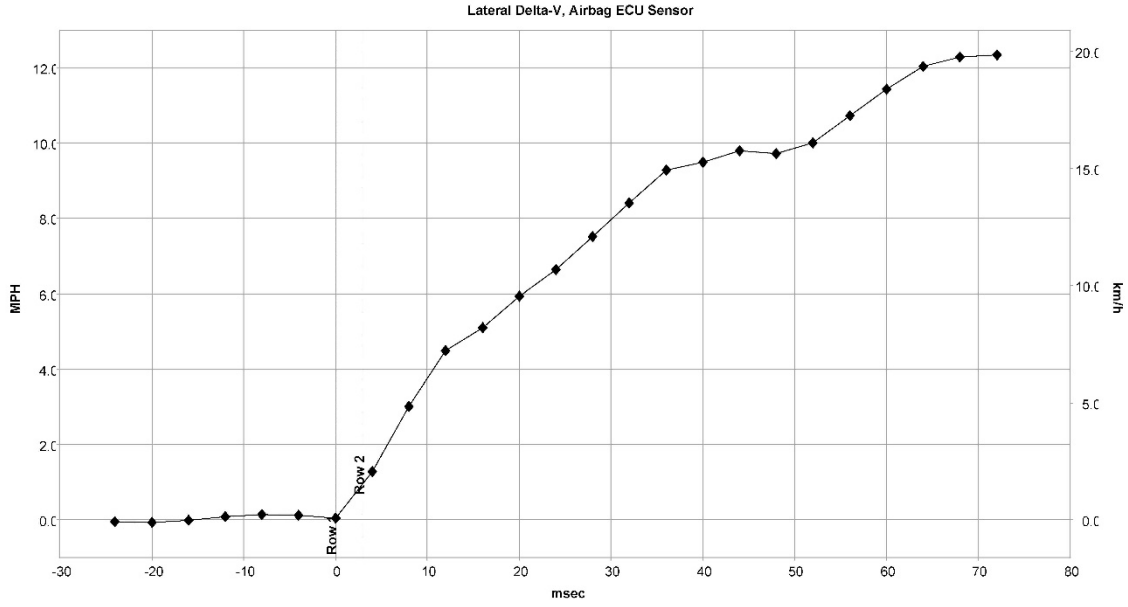
Events Recorded	TRG Count	Crash Type	Time (msec)	Pre-Crash and/or DTC Data Recording Status	Event & Crash Pulse Data Recording Status
Most Recent Event	9	Side Crash	0	Complete (Page 1)	Complete (Side Page 0)
1st Prior Event	8	Front/Rear Crash	-16381 or greater	Complete (Page 0)	Complete (Front/Rear Page 0)
2nd Prior Event	7	Front/Rear Crash	N/A	N/A	Complete (Front/Rear Page 1)
3rd Prior Event	6	Side Crash	N/A	N/A	Complete (Side Page 1)

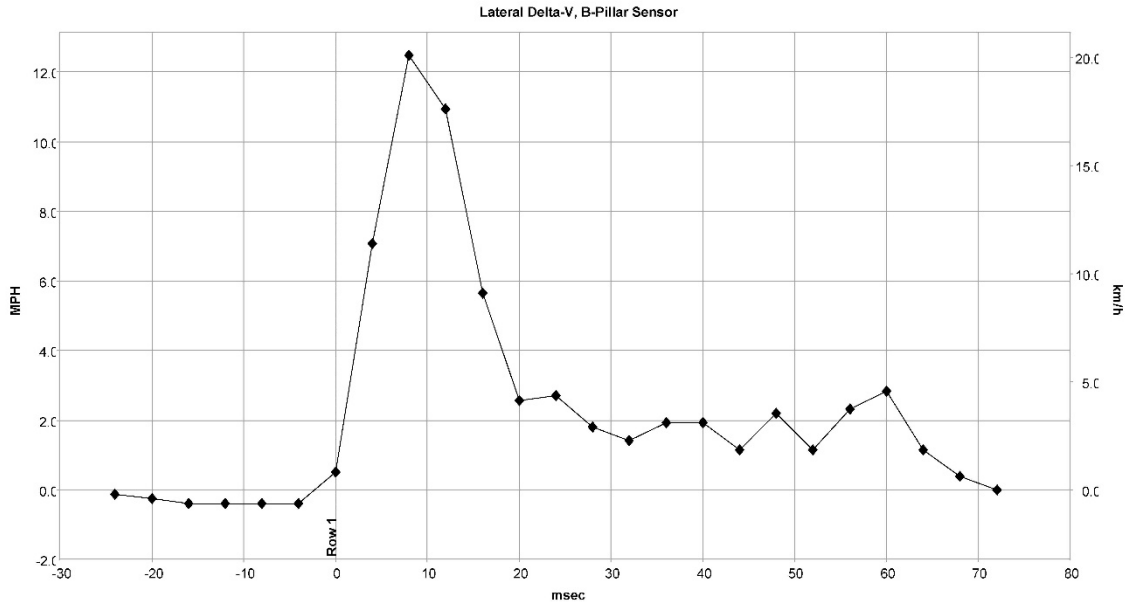
System Status at Event (Most Recent Event, TRG 9)

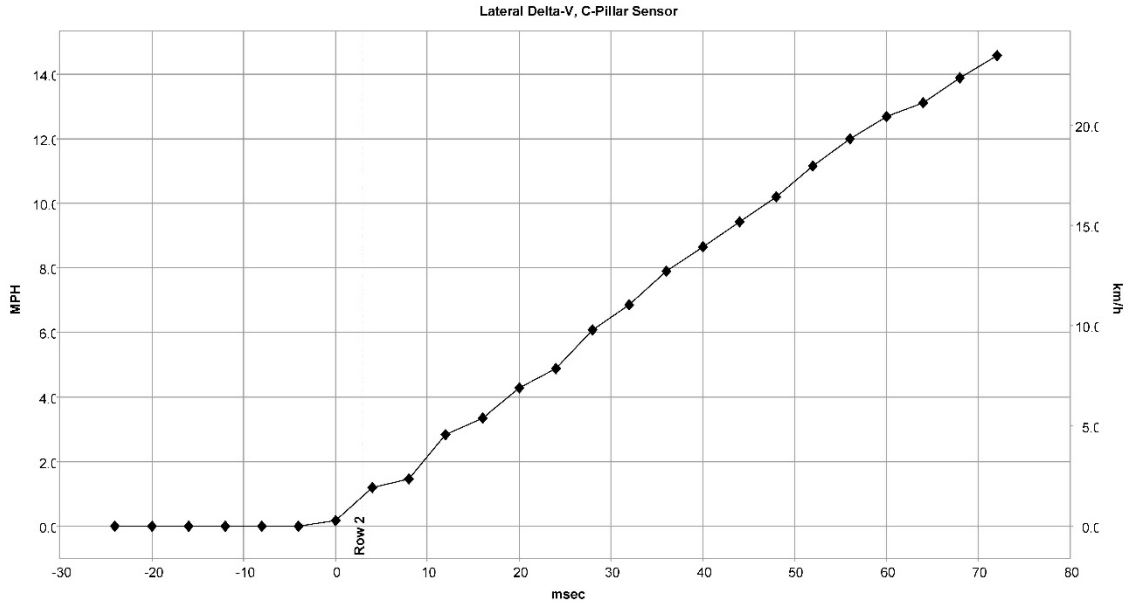
Recording Status, Side Crash Info.	Complete
Crash Type	Side Crash
TRG Count (times)	9
Recorded Side	Driver's Side
Previous Crash Type	Frontal/Rear
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	1
Time to Deployment Command, B-Pillar Sensor (msec)	0
Time to Deployment Command, C-Pillar Sensor (msec)	3

Lateral Crash Pulse (Most Recent Event, TRG 9 - table 1 of 2)

Recording Status, Time Series Data	Complete
Time from TRG to Next Sample (msec)	0
Max Lateral Delta-V, B-Pillar Sensor (MPH [km/h])	12.5 [20.1]
Max Lateral Delta-V, C-Pillar Sensor (MPH [km/h])	14.6 [23.4]






Lateral Delta-V, C-Pillar Sensor
MPH
km/h
msec
Row 2
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
20.0
15.0
10.0
5.0
0.0
-30
-20
-10
0
10
20
30
40
50
60
70
80

Lateral Crash Pulse (Most Recent Event, TRG 9 - table 2 of 2)

Time (msec)	Lateral Delta-V, Airbag ECU Sensor (MPH [km/h])	Lateral Delta-V, B-Pillar Sensor (MPH [km/h])	Lateral Delta-V, C-Pillar Sensor (MPH [km/h])
-24	-0.1 [-0.1]	-0.1 [-0.2]	0.0 [0.0]
-20	-0.1 [-0.1]	-0.3 [-0.4]	0.0 [0.0]
-16	0.0 [0.0]	-0.4 [-0.6]	0.0 [0.0]
-12	0.1 [0.1]	-0.4 [-0.6]	0.0 [0.0]
-8	0.1 [0.2]	-0.4 [-0.6]	0.0 [0.0]
-4	0.1 [0.2]	-0.4 [-0.6]	0.0 [0.0]
0	0.1 [0.1]	0.5 [0.8]	0.2 [0.3]
4	1.3 [2.1]	7.1 [11.4]	1.2 [1.9]
8	3.0 [4.8]	12.5 [20.1]	1.5 [2.3]
12	4.5 [7.2]	10.9 [17.6]	2.8 [4.6]
16	5.1 [8.2]	5.7 [9.1]	3.3 [5.4]
20	5.9 [9.5]	2.6 [4.1]	4.3 [6.9]
24	6.6 [10.7]	2.7 [4.3]	4.9 [7.9]
28	7.5 [12.1]	1.8 [2.9]	6.1 [9.8]
32	8.4 [13.5]	1.4 [2.3]	6.9 [11.0]
36	9.3 [14.9]	1.9 [3.1]	7.9 [12.7]
40	9.5 [15.3]	1.9 [3.1]	8.7 [13.9]
44	9.8 [15.8]	1.2 [1.9]	9.4 [15.2]
48	9.7 [15.6]	2.2 [3.5]	10.2 [16.4]
52	10.0 [16.1]	1.2 [1.9]	11.1 [17.9]
56	10.7 [17.2]	2.3 [3.7]	12.0 [19.3]
60	11.4 [18.4]	2.8 [4.6]	12.7 [20.4]
64	12.0 [19.4]	1.2 [1.9]	13.1 [21.1]
68	12.3 [19.8]	0.4 [0.6]	13.9 [22.3]
72	12.3 [19.9]	0.0 [0.0]	14.6 [23.4]

DTCs Present at Time of Event (Most Recent Event, TRG 9)

Recording Status, Diagnostic	Complete
Ignition Cycle Since DTC was Set (times)	1217
Airbag Warning Lamp ON Time Since DTC was Set (min)	28,020
Diagnostic Trouble Code (1)	51
Diagnostic Trouble Code (2)	53

Pre-Crash Data, 1 Sample (Most Recent Event, TRG 9)

Recording Status, Pre-Crash/Occupant	Complete
Time from Pre-Crash to TRG (msec)	600
Buckle Switch, Driver	Buckled
Buckle Switch, Passenger	Unbuckled
Occupancy Status, Passenger	Not Occupied
Seat Position, Driver	Rearward
Shift Position	Drive

Pre-Crash Data, -5 to 0 seconds (Most Recent Event, TRG 9)

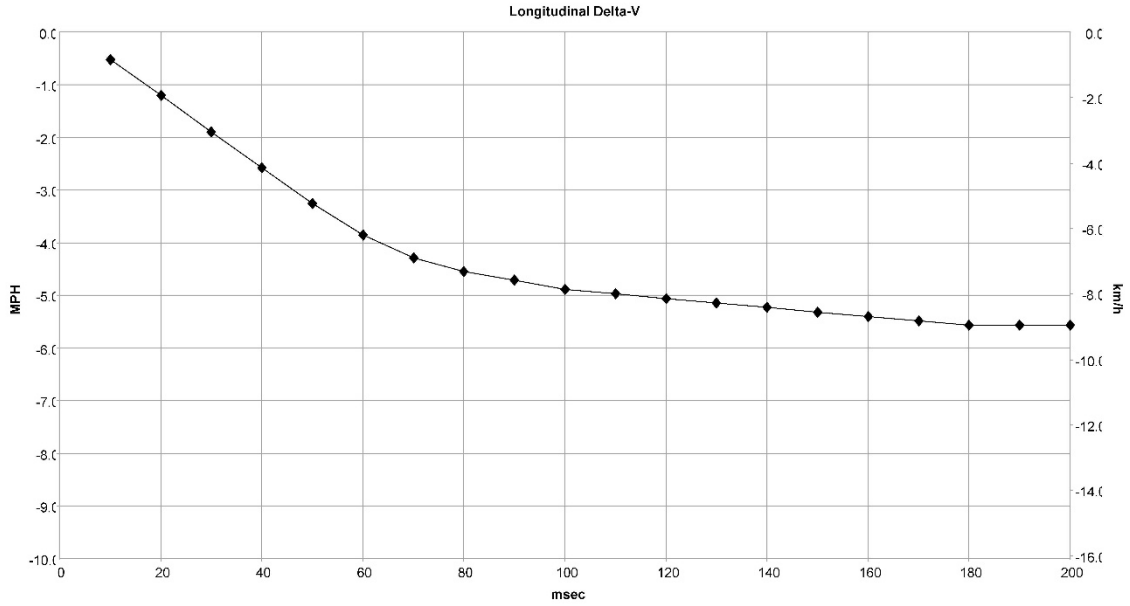
Time (sec)	-4.6	-3.6	-2.6	-1.6	-0.6	0 (TRG)
Vehicle Speed (MPH [km/h])	75.8 [122]	75.8 [122]	75.8 [122]	75.8 [122]	75.8 [122]	64.6 [104]
Brake Switch	OFF	ON	ON	ON	ON	OFF
Accelerator Rate (V)	2.89	0.78	0.78	0.78	0.78	0.78
Engine RPM (RPM)	5,200	4,400	2,800	2,800	2,000	1,200

System Status at Event (1st Prior Event, TRG 8)

Recording Status, Front/Rear Crash Info.	Complete
Crash Type	Front/Rear Crash
TRG Count (times)	8
Previous Crash Type	No Event
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	0
Time to Deployment Command, Front Airbag, Driver (msec)	Not Commanded
Time to Deployment Command, Front Airbag, Passenger (msec)	Not Commanded
Event Severity Status, Driver	N/A
Event Severity Status, Passenger	N/A
Time to Deployment Command, Pretensioner (msec)	Not Commanded

Longitudinal Crash Pulse (1st Prior Event, TRG 8 - table 1 of 2)

Recording Status, Time Series Data	Complete
Max Longitudinal Delta-V (MPH [km/h])	-5.6 [-9.0]



Longitudinal Crash Pulse (1st Prior Event, TRG 8 - table 2 of 2)

Time (msec)	Longitudinal Delta-V (MPH [km/h])
10	-0.5 [-0.8]
20	-1.2 [-1.9]
30	-1.9 [-3.0]
40	-2.6 [-4.1]
50	-3.3 [-5.2]
60	-3.9 [-6.2]
70	-4.3 [-6.9]
80	-4.5 [-7.3]
90	-4.7 [-7.6]
100	-4.9 [-7.9]
110	-5.0 [-8.0]
120	-5.1 [-8.1]
130	-5.1 [-8.3]
140	-5.2 [-8.4]
150	-5.3 [-8.6]
160	-5.4 [-8.7]
170	-5.5 [-8.8]
180	-5.6 [-9.0]
190	-5.6 [-9.0]
200	-5.6 [-9.0]

DTCs Present at Time of Event (1st Prior Event, TRG 8)

Recording Status, Diagnostic	Complete
Ignition Cycle Since DTC was Set (times)	1216
Airbag Warning Lamp ON Time Since DTC was Set (min)	28,005
Diagnostic Trouble Code (1)	51
Diagnostic Trouble Code (2)	53

Pre-Crash Data, 1 Sample (1st Prior Event, TRG 8)

Recording Status, Pre-Crash/Occupant	Complete
Time from Pre-Crash to TRG (msec)	0
Buckle Switch, Driver	Buckled
Buckle Switch, Passenger	Unbuckled
Occupancy Status, Passenger	Not Occupied
Seat Position, Driver	Rearward
Shift Position	Drive

Pre-Crash Data, -5 to 0 seconds (1st Prior Event, TRG 8)

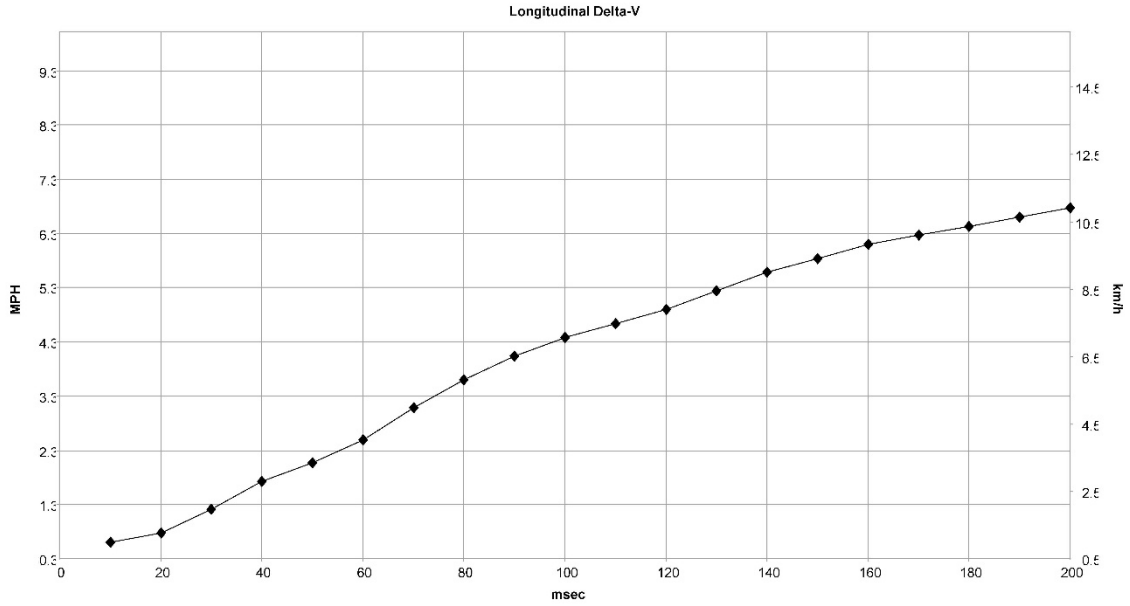
Time (sec)	-4	-3	-2	-1	0	0 (TRG)
Vehicle Speed (MPH [km/h])	36 [58]	36 [58]	34.8 [56]	33.6 [54]	21.1 [34]	11.2 [18]
Brake Switch	OFF	OFF	OFF	ON	ON	ON
Accelerator Rate (V)	0.78	1.09	1.02	0.78	0.78	0.78
Engine RPM (RPM)	1,200	1,600	1,600	1,200	400	400

System Status at Event (2nd Prior Event, TRG 7)

Recording Status, Front/Rear Crash Info.	Complete
Crash Type	Front/Rear Crash
TRG Count (times)	7
Previous Crash Type	No Event
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	1
Time to Deployment Command, Front Airbag, Driver (msec)	Not Commanded
Time to Deployment Command, Front Airbag, Passenger (msec)	Not Commanded
Event Severity Status, Driver	N/A
Event Severity Status, Passenger	N/A
Time to Deployment Command, Pretensioner (msec)	Not Commanded

Longitudinal Crash Pulse (2nd Prior Event, TRG 7 - table 1 of 2)

Recording Status, Time Series Data	Complete
Max Longitudinal Delta-V (MPH [km/h])	6.8 [10.9]



Longitudinal Crash Pulse (2nd Prior Event, TRG 7 - table 2 of 2)

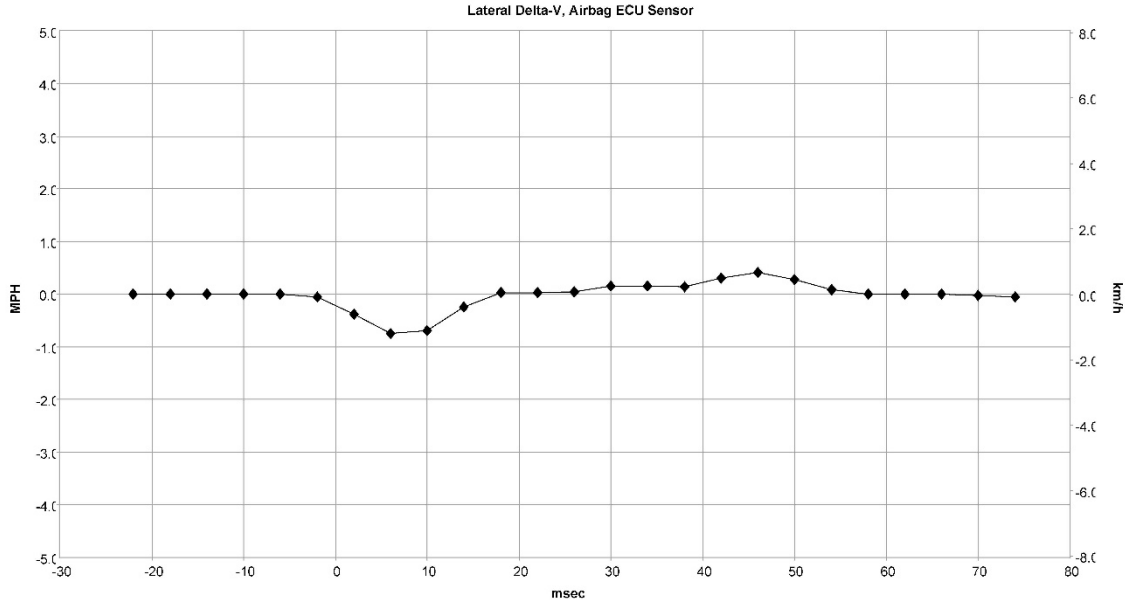
Time (msec)	Longitudinal Delta-V (MPH [km/h])
10	0.6 [1.0]
20	0.8 [1.2]
30	1.2 [1.9]
40	1.7 [2.8]
50	2.1 [3.3]
60	2.5 [4.0]
70	3.1 [5.0]
80	3.6 [5.8]
90	4.0 [6.5]
100	4.4 [7.0]
110	4.6 [7.4]
120	4.9 [7.9]
130	5.2 [8.4]
140	5.6 [9.0]
150	5.8 [9.4]
160	6.1 [9.8]
170	6.3 [10.1]
180	6.4 [10.3]
190	6.6 [10.6]
200	6.8 [10.9]

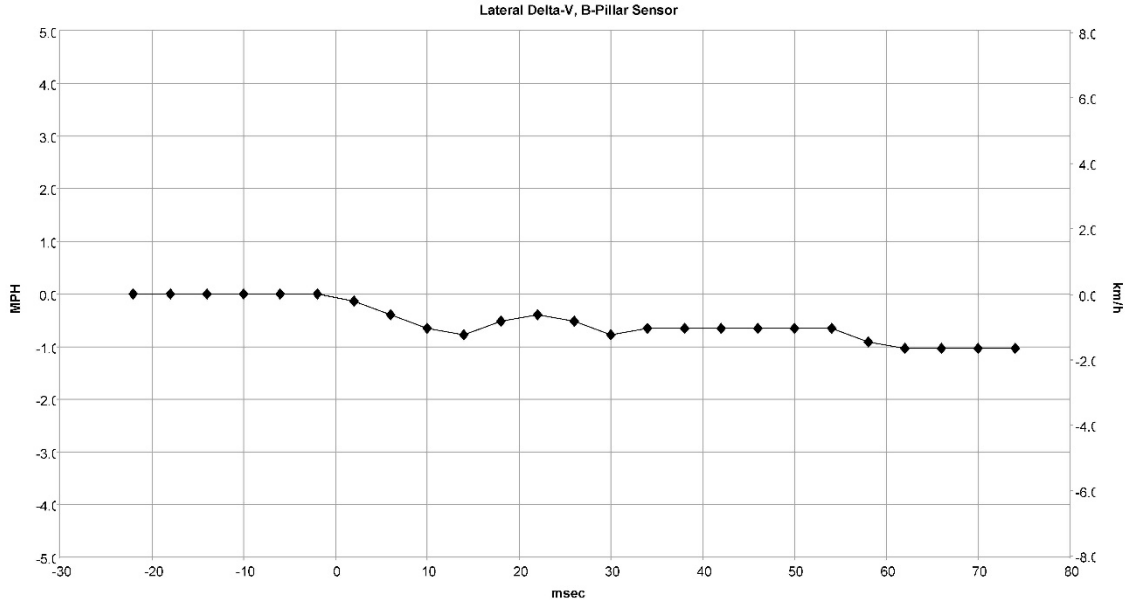
System Status at Event (3rd Prior Event, TRG 6)

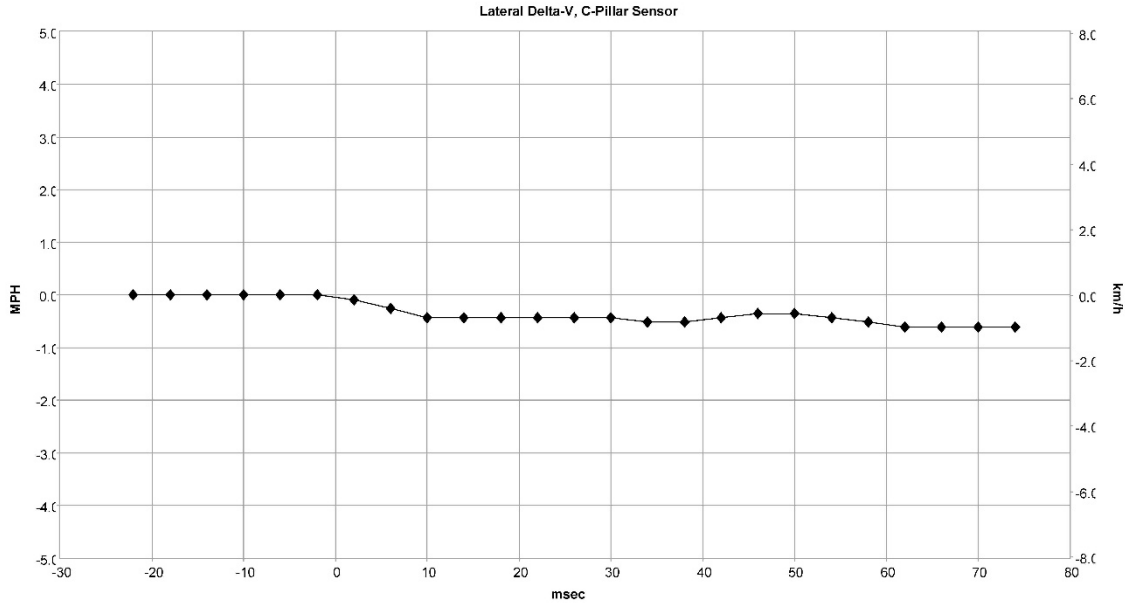
Recording Status, Side Crash Info.	Complete
Crash Type	Side Crash
TRG Count (times)	6
Recorded Side	Driver's Side
Previous Crash Type	No Event
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	0
Time to Deployment Command, B-Pillar Sensor (msec)	Not Commanded
Time to Deployment Command, C-Pillar Sensor (msec)	Not Commanded

Lateral Crash Pulse (3rd Prior Event, TRG 6 - table 1 of 2)

Recording Status, Time Series Data	Complete
Time from TRG to Next Sample (msec)	2
Max Lateral Delta-V, B-Pillar Sensor (MPH [km/h])	-1.0 [-1.7]
Max Lateral Delta-V, C-Pillar Sensor (MPH [km/h])	-0.6 [-1.0]






Lateral Delta-V, C-Pillar Sensor
MPH
km/h
msec
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-30
-20
-10
0
10
20
30
40
50
60
70
80

Lateral Crash Pulse (3rd Prior Event, TRG 6 - table 2 of 2)

Time (msec)	Lateral Delta-V, Airbag ECU Sensor (MPH [km/h])	Lateral Delta-V, B-Pillar Sensor (MPH [km/h])	Lateral Delta-V, C-Pillar Sensor (MPH [km/h])
-22	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-18	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-14	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-10	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-6	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-2	-0.1 [-0.1]	0.0 [0.0]	0.0 [0.0]
2	-0.4 [-0.6]	-0.1 [-0.2]	-0.1 [-0.1]
6	-0.7 [-1.2]	-0.4 [-0.6]	-0.3 [-0.4]
10	-0.7 [-1.1]	-0.6 [-1.0]	-0.4 [-0.7]
14	-0.2 [-0.4]	-0.8 [-1.2]	-0.4 [-0.7]
18	0.0 [0.1]	-0.5 [-0.8]	-0.4 [-0.7]
22	0.0 [0.1]	-0.4 [-0.6]	-0.4 [-0.7]
26	0.1 [0.1]	-0.5 [-0.8]	-0.4 [-0.7]
30	0.2 [0.2]	-0.8 [-1.2]	-0.4 [-0.7]
34	0.2 [0.2]	-0.6 [-1.0]	-0.5 [-0.8]
38	0.1 [0.2]	-0.6 [-1.0]	-0.5 [-0.8]
42	0.3 [0.5]	-0.6 [-1.0]	-0.4 [-0.7]
46	0.4 [0.7]	-0.6 [-1.0]	-0.3 [-0.6]
50	0.3 [0.4]	-0.6 [-1.0]	-0.3 [-0.6]
54	0.1 [0.1]	-0.6 [-1.0]	-0.4 [-0.7]
58	0.0 [0.0]	-0.9 [-1.4]	-0.5 [-0.8]
62	0.0 [0.0]	-1.0 [-1.7]	-0.6 [-1.0]
66	0.0 [0.0]	-1.0 [-1.7]	-0.6 [-1.0]
70	0.0 [0.0]	-1.0 [-1.7]	-0.6 [-1.0]
74	-0.1 [-0.1]	-1.0 [-1.7]	-0.6 [-1.0]

Hexadecimal Data

Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR system.

PIDs

PID	Data
00	BE E0 00 01
01	00
03	33 33 34 39 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30
04	FF 01 FF FF
05	02
06	12
07	30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30
09	
0A	01
0B	00
20	80 00 00 01
21	00 31
40	00 00 00 01
60	00 00 00 01
80	00 00 00 01
A0	00 00 00 01
C0	00 00 00 01
E0	C0 10 00 00
E1	16 16
E2	00 5B 1F 11 00
EC	FF

EEPROM

Address	Data (-- = data not imaged from ECU) (** = no response from ECU)
0	-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
10	-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20	-- -- -- -- -- -- -- -- -- -- -- -- -- -- 04 C1
30	00 00 4F 01 7F FD 07 4C A5 04 00 12 FF FF FF FF
40	FF FF FF FF FF FF FF FF FF FF FF FF FF FF -- --
50	-- -- 10 01 01 25 14 11 45 14 34 6D 14 43 70 1A
60	74 1C 74 14 00 00 00 00 51 53 00 00 00 00 00 00
70	00 00 00 00 04 C0 07 4B 00 00 10 01 01 D0 14 35
80	F5 14 77 F5 14 BD F5 14 F5 14 F4 4A 06 00 00 00
90	51 53 00 00 00 00 00 00 00 00 00 00 04 C1 07 4C
A0	00 00 -- -- 06 08 08 08 08 07 05 03 02 02 01 01
B0	01 01 01 01 01 01 00 00 00 CD 00 00 00 08 E0 00
C0	FE FE 00 00 F9 FE FB FA FC FB F9 FA FB FC FD FD
D0	FC FC FD FD FE FE FE FE FE 8F 00 00 00 07 E4 00
E0	FE FE 00 00 -- -- FF FF FF 00 00 00 07 33 2A F4
F0	D7 E8 01 F9 FD 04 00 FA 08 F8 09 04 F3 FA FD 00
100	00 00 00 00 00 02 0C 03 10 06 0B 07 0E 09 0C 09
110	09 09 0B 0A 08 05 09 08 03 01 FD FA FD 01 04 B8
120	9C A9 DD CF D7 CD CC CD F4 EE 04 F0 D6 D7 DC F2
130	FC 00 00 00 00 09 04 00 00 03 00 00 00 00 00 00
140	00 00 FF FE FE FF 02 01 FF FE 01 00 00 00 00 00
150	FE FF 00 00 00 00 00 00 00 00 00 FF FE FE 00 00
160	00 00 00 FF 00 01 01 00 FF FF FF 00 00 00 00 00
170	00 00 00 03 13 15 FD E6 F0 00 FF FA 00 01 F6 FA
180	08 0B 05 00 00 01 02 00 20 00 00 06 E0 00 FE FE
190	00 00

Disclaimer of Liability

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**National Highway
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Administration**

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