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Special Crash Investigations
On-Site Air Bag Non-Deployment Investigation
Vehicle: 2018 Toyota Corolla
Location: California
Crash Date: May 2018

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Each crash represents a unique sequence of events and 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 this report was published.

16. Abstract

This report documents the on-site investigation of the non-deployment of air bags and the injuries sustained by the driver and front right passenger of a 2018 Toyota Corolla. This three-vehicle crash occurred on a four-lane divided interstate highway in California in the morning in May 2018. The Toyota was traveling southbound at a VCH-reported speed of 138- to 143 km/h (86-89 mph) 5 seconds prior to impact. The Toyota was occupied by a belted 23-year-old female driver and a belted 22-year-old female front right occupant. A 2017 Ford Expedition was in the third lane from the right, ahead of the Toyota, and had slowed to an EDR-reported speed of 2 km/h (1 mph). The Ford was being driven by a belted 39-year-old female. The front right seat occupant was a belted 54-year-old male. There were two second row occupants, a belted 12-year- old male and a belted 13-year-old male. A 2016 Freightliner tractor pulling a trailer was traveling at an unknown speed ahead of both vehicles. The Freightliner was being driven by a 48-year-old male. The Freightliner was changing lanes from the second lane from the right to the right lane. For unknown reasons, the driver of the Toyota was unable to stop in time and struck the rear of the Ford. There were no air bag deployments. The Toyota was displaced to the right, where it struck the left side of the Freightliner. All vehicles came to rest on the roadway. The Toyota and Ford were towed from the scene. The Freightliner was driven from the scene. The driver of the Toyota sustained fatal injuries and was declared deceased at the scene. The front right occupant of the Toyota sustained “A” serious type injuries and was transported from the scene by ambulance. All occupants of the Ford complained of pain or sustained minor injuries. They were all transported from the scene by ambulance. The driver of the Freightliner did not report any injuries. Based on the extent of damage and impact configuration there should have been frontal air bag deployments in the Toyota.

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OFFICE OF DEFECTS INVESTIGATION
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VEHICLE: 2018 TOYOTA COROLLA
LOCATION: CALIFORNIA
CRASH DATE: MAY 2018

BACKGROUND

This report documents the on-site investigation of the non-deployment of air bags and the injuries sustained by the driver and front right passenger of a 2018 Toyota Corolla (**Figure 1**) that was involved in a multi-vehicle crash. This case was initiated in response to a police notification made to the National Highway Traffic Safety Administration. The Special Crash Investigations (SCI) group assigned the case to Dynamic Science, Inc., in October 2018. The driver of the Toyota was fatally injured. The front right passenger sustained serious injuries. The investigation intended to determine occupant restraint usage, kinematics, injury sources, and air bag deployment non-deployment specifics for the Toyota. The vehicle was configured with front air bags for the front row occupants, seat-mounted side air bags for the front row, driver knee bag, a seat-cushion air bag for the front right seat, and inflatable curtain (IC) air bags for both rows.

Figure 1. 2018 Toyota Corolla, front damage.

The Toyota was supported by the Bosch Crash Data Retrieval (CDR). The investigating police agency was unable to image the vehicle's event data recorder (EDR). The module was removed and efforts were made by CHP to swap the module's memory chip with the chip from an exemplar module. This effort was unsuccessful. SCI retrieved the vehicle module and an exemplar module from the police agency and shipped them to NHTSA in September 2018 for analysis. The CDR data was retrieved and contained no information other than key cycle information. Toyota was able to download vehicle control history (VCH) data.

The vehicle inspection occurred in November 2018. Present at the inspection were representatives from Toyota, attorneys and investigators representing the vehicle driver, NHTSA's Vehicle Research and Test Center (VRTC), and the investigating police agency.

This three-vehicle crash occurred on a four-lane, divided, interstate highway in California in the morning in May 2018. The concrete roadway was straight and level. It was dark at the time of

the crash and there were no streetlights present. The Toyota was traveling southbound at a VCH-reported speed of 138- to 143 km/h (86-89 mph) 5 seconds prior to impact. The Toyota was occupied by a belted 23-year-old female driver and a belted 22-year-old female front right occupant. A 2017 Ford Expedition was in the third lane from the right, ahead of the Toyota, and had slowed to an EDR-reported speed of 2 km/h (1 mph). The Ford was driven by a belted 39-year-old female. The front right seat occupant was a belted 54-year-old male. There were two second row occupants, a belted 12-year-old male and a belted 13-year-old male. A 2016 Freightliner tractor pulling a trailer was traveling at an unknown speed ahead of the other vehicles. The Freightliner was driven by a 48-year-old male. The Freightliner was changing lanes from the second lane from the right to the right lane. For unknown reasons, the driver of the Toyota was unable to stop in time and struck the rear of the Ford. There were no air bag deployments (**Figure 2**). The Toyota was displaced to the right where it struck the left side of the Freightliner.

Figure 2. Driver's air bag, 2018 Toyota Corolla.

All the vehicles came to rest on the roadway. The Toyota and Ford were towed from the scene. The Freightliner was driven from the scene. The driver of the Toyota sustained fatal injuries and was declared deceased at the scene. The front right occupant of the Toyota sustained "A" serious type injuries and was transported from the scene by ambulance. All the occupants of the Ford complained of pain or sustained minor injuries. They were all transported from the scene by ambulance. The driver of the Freightliner did not report any injuries.

Based on the extent of damage and impact configuration there should have been frontal air bag deployments in the Toyota.

SUMMARY

Crash Site

The crash site was in the southbound lanes of a divided interstate highway (**Figure 3**). The concrete roadway was straight and level. There were four travel lanes that were separated by dashed white lines and raised ceramic markers. The roadway was bordered on the west by a solid white line and an asphalt shoulder followed by a descending dirt embankment with shrubs and trees. On the east, the roadway was bordered by a solid yellow line and a concrete median barrier. This crash occurred during morning hours and there were no streetlights at or around the crash scene. The posted speed limit was 105 km/h (65 mph). The roadway was dry and the weather at the nearest reporting station was 15.5 °C (60 °F), 80 percent humidity, cloudy, and the winds were out of the west northwest at 9.6 km/h (6 mph). A crash diagram is attached at the end of this technical report.

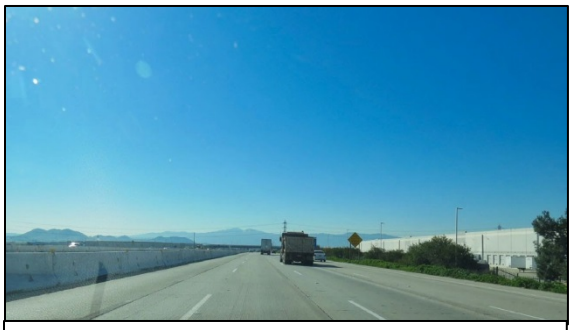

Figure 3. Southbound view.

Pre-Crash

Approximately 2 hours prior to this crash there had been a fatal crash in the same area. There had been lane closures and traffic was being redirected and slowed.

The Toyota stored information about non-crash events in the VCH records. VCH records can be triggered by multiple types of events, including activation of the antilock braking system (ABS) and the pre-collision system (PCS). The Toyota PCS uses a millimeter wave radar and a camera to detect potential hazards and initiate autonomous emergency braking (AEB). The PCS is discussed further later in this report.

The Toyota was traveling southbound. During its journey, the VCH recorded three PCS triggers, one ABS trigger, and one sudden braking trigger. The final PCS trigger was related to this crash. The Toyota was traveling southbound in the third lane from the right. At 5 seconds prior to the trigger the vehicle speed was 138- to 143 km/h (86-89 mph) and brake switch status was off. The following table was generated using speeds from VCH data, the deceleration rate of -8.03 m/s/s at -1.15 seconds, and an inline closing calculation.

Time	Vehicle Speed		Distance Traveled			
			Incremental		Cumulative	
-sec	km/h	mph	m	ft	m	ft
5	140	87	NA	NA	NA	NA
4.5	140	87	19.4	63.8	19.4	63.8
4	140	87	19.4	63.8	38.9	127.6
3.5	140	87	19.4	63.8	58.3	191.4
3	140	87	19.4	63.8	77.8	255.2
2.5	140	87	19.4	63.8	97.2	319
2	140	87	19.4	63.8	116.7	382.8
1.5	140	87	19.4	63.8	136.1	446.6
1	121	75	16.8	55	152.9	501.6
0.5	103	64	14.3	46.9	167.2	548.5
0	92	57	12.7	41.8	179.9	590.3

It should be noted that the vehicle speedometer was locked at 121 km/h (75 mph) (**Figure 4**). This was likely due to damage as opposed to a power loss since other display items were in their power off positions.

Figure 4. Speedometer, 2018 Toyota Corolla.

The Ford Expedition was in the third lane from the right, ahead of the Toyota, and had slowed from an EDR-reported speed of 11 km/h (7 mph) to 2 km/h (1 mph). An overview of the Ford's speed and distance traveled as reported by the EDR is shown in the following table.

Time	Vehicle Speed		Distance Traveled			
			Incremental		Cumulative	
- sec	km/h	mph	m	ft	m	ft
5	11	7	NA	NA	NA	NA
4.5	10	6	1.3	4.4	1.3	4.4
4	8	5	1.1	3.7	2.5	8.1
3.5	6	4	0.9	2.9	3.4	11
3	3	2	0.5	1.5	3.8	12.5
2.5	2	1	0.2	0.7	4	13.2
2	2	1	0.2	0.7	4.2	13.9
1.5	0	0	0	0	4.2	13.9
1	0	0	0	0	4.2	13.9
0.5	2	1	0.2	0.7	4.5	14.6
0	2	1	0.2	0.7	4.7	15.3

The Freightliner tractor pulling a trailer was traveling at an unknown speed ahead of the other involved vehicles. The Freightliner was changing lanes from the second lane from the right to the right lane.

At 1 second prior to the trigger the driver of the Toyota began braking. The PCS warning alarm actuated and PCS brake assist activated approximately 0.5 seconds later. The calculated inline closing speed was calculated to be 94.7 km/h (58.9 mph) using a coefficient of restitution of 0.1 and the pre-impact travel speed of the Ford of 2 km/h (1 mph).[1] Based on VCH data, the combination of the driver's brake input and the PCS system reduced the vehicle speed by 32 km/h (20 mph) to approximately 106-111 km/h (66-69 mph) prior to impact.

Crash

The front of the Toyota struck the rear of the nearly stopped Ford (Event 1). The missing vehicle algorithm of the WinSMASH program calculated a total delta V of 63 km/h (39 mph) for the Toyota. The longitudinal and lateral components were -63 km/h (-39 mph) and 0 km/h, respectively. The barrier equivalent speed (BES) was 59 km/h (37 mph). The collision fit the model and the results appear reasonable. The calculated delta V for the Toyota using the known delta V of the Ford was 69.6 km/h (43.3).[2] There were no air bag deployments in this vehicle.

The program calculated a Total delta V of 33 km/h (21 mph) for the Ford. The longitudinal and lateral components were 33 km/h (21 mph) and 0 km/h, respectively. The BES was 37 km/h (23 mph). The EDR reported a maximum longitudinal velocity change of 32.8 km/h (20.38 mph) for the Ford.

The Ford was displaced forward and to the left approximately 37 m (121 ft) and came to rest in the fourth lane from the right. The Toyota traveled forward and to the right approximately 38 m (124 ft) where it lightly struck the left side of the Freightliner (Event 2).

Post-Crash

All the vehicles came to rest on the roadway. The Toyota and Ford were towed from the scene due to damage. The Freightliner was driven from the scene. The driver of the Toyota sustained fatal injuries and was declared deceased at the scene. The front right occupant of the Toyota sustained "A" incapacitating injuries. EMS was notified at 0110 hours and arrived on-scene at 0119. The right front occupant was extricated by EMS personnel who noted that she had a loss of consciousness and was inebriated. She was transported by ambulance to a local trauma center where she arrived at 0143 hours with a Glasgow Coma Scale score of 14 and was amnesiac to the crash events. She was admitted with a sacral fracture, ruptured bladder, and multiple contusions/abrasions. She was hospitalized for 5 days.

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[1] Inline closing speed = $(|\Delta V_{Toyota}| + |\Delta V_{Ford}|) * (1/1+e))$ $58.9 = ((43.3 + 20.38) * 0.91) + 1$

[2] $\Delta V_{Toyota} = \Delta V_{Ford} (W_{Ford} / W_{Toyota})$ $43.3 = 20.38 (6460/3035)$

All the occupants of the Ford complained of pain or sustained minor injuries. They were all transported from the scene by ambulance. The driver of the Freightliner did not report any injuries.

2018 TOYOTA COROLLA

Description

The Toyota Corolla was a 5-passenger, 4-door sedan. The vehicle was identified by the Vehicle Identification Number (VIN) 5YFBURHEXJPxxxxxx with a manufacture date of November 2017. The vehicle was equipped with a 1.8-liter, 4-cylinder, gasoline engine, front wheel drive, and 4-wheel ABS. The vehicle manufacturer's recommended tire size was P205/55R16 with a cold pressure of 221 kPa (32 psi). The vehicle was equipped with Michelin Primacy radial tires of the recommended size. The specific tire information was as follows:

Position	Measured Tread Depth	Restricted	Damage
LF	3 mm (4/32 in)	Yes	No
LR	4 mm (5/32 in)	No	No
RR	3 mm (4/32 in)	No	No
RF	Unknown	Yes	Debeaded

Exterior Damage

The Toyota sustained severe frontal damage from the impact with the rear plane of the Ford (**Figure 5**). The Field L extended from bumper corner to bumper corner. Fourteen measurements were taken at the backing bar level by the Nikon Total Station and the Faro Blitz program computed crush measurement in six increments as follows: C1 = 8 cm (3.1 in), C2 = 25 cm (9.8 in), C3 = 60 cm (23.6 in), C4 = 55 cm (21.6 in), C5 = 49 cm (19.2 in), C6 = 30 cm (11.8 in). The vehicle also sustained above bumper override crush. Crush at the radiator support was measured as follows: C1 = 36 cm (14.1 in), C2 = 34 cm (13.3 in), C3 = 42 cm (16.5 in), C4 = 35 cm (13.7 in), C5 = 41 cm (16.1 in), C6 = 67 cm (26.3 in). The averaged crush was as follows: C1 = 24 cm (9.4 in), C2 = 25 cm (9.8 in), C3 = 51 cm (20.0 in), C4 = 45 cm (17.7 in), C5 = 49 cm (19.2 in), C6 = 49 cm (19.2 in). The Collision

Figure 5. Frontal damage, 2018 Toyota Corolla.

Deformation Classification (CDC) was 12FDEW3. There was no evidence of the light contact to the Freightliner in Event 2.

Event Data Recorder

The Toyota was equipped with an electronic control unit (ECU) that had EDR capability to store deployment and non-deployment events. Both types of events can contain pre-crash and crash data. Police investigators initially attempted to image the ECU by connecting directly to the ECU while still installed in the vehicle. This attempt was unsuccessful and the ECU was removed for later analysis. A second attempt was made to image the ECU directly with Toyota representatives present. They were unable to establish communication with the ECU and no image was obtained. An exemplar ECU was obtained to be used as a surrogate module for an EEPROM transplant. After the transplant, the surrogate ECU (with the EEPROM from the ECU installed in the Toyota) was successfully imaged (see **Appendix A**). There were no events recorded. The investigators attempted to image the ECU from the Toyota with the transplanted EEPROM the surrogate ECU but were unable to establish communication with the ECU, suggesting there was fault with the circuit board of the ECU removed from the Toyota.

SCI retrieved the vehicle ECU and the surrogate ECU from the police agency and shipped them to NHTSA in September 2018 for analysis. Toyota was later able to obtain vehicle control history from the vehicle.

NHTSA Recalls and Investigations

Based on the VIN, there were recalls or investigations when the database was last queried in August 2019.

Interior Damage

The Toyota sustained moderate interior damage from intrusions and occupant contacts. There was longitudinal intrusion to the instrument panel. The steering wheel column was compressed and the steering wheel rim was deformed from occupant loading. There were also occupant contacts to the right and left upper instrument panel, and the driver's lower instrument panel. All the doors remained closed and operational. The windshield sustained damage from the hood. The backlight was broken out, likely by rescue personnel. The remaining glazing was undamaged.

Figure 6. Driver's safety belt, 2018 Toyota Corolla.

Manual Restraint Systems

The front row was equipped with driver and front right passenger lap and shoulder safety belts. The driver's belt was equipped with continuous loop belt webbing, a sliding latch plate, an emergency locking retractor (ELR), and an adjustable upper anchor that was adjusted to the full down position. The front right passenger's safety belt was equipped the same as the driver's, but had a switchable ELR/automatic locking retractor (ALR). Both front row safety belts exhibited loading evidence (**Figures 6-7**). Driver loading of the safety belt webbing caused scuff marks and stretch marks at the latch plate. Passenger loading of the safety belt webbing caused scuff marks and stretch marks measuring 42 cm (16.5 in) located 104 cm (40.9 in) above the stop button. Both safety belts were equipped with retractor pretensioners that did not actuate.

Figure 7. Front right passenger safety belt, 2018 Toyota Corolla.

Supplemental Restraint Systems

The Toyota was equipped with dual-stage frontal air bags for the driver and front right passenger positions, seat-mounted side air bags, driver knee air bag, passenger seat cushion air bag and side impact Inflatable Curtain (IC) air bags for the front and second row seats. There were no air bag deployments.

Air Bag Non-Deployment Discussion

The vehicle was configured with an air bag sensor assembly, front impact sensors, side impact sensors (front doors), and side impact sensors (front and rear). The dual front impact sensors were located the vehicle body above the backing bar on the frame rails. The sensors share power with additional vehicle components. The left sensor wiring was damaged during the crash (**Figure 8**). The left wiring assembly was not removed from the vehicle. During the inspection, there was a fuse inventory conducted. It was determined that all the fuses in the engine compartment location were intact.

Figure 8. Left air bag sensor at left front corner, 2018 Toyota Corolla.

Based on the extent of damage and impact configuration there should have been frontal air bag deployments in the Toyota.

Crash Avoidance Technology
The Toyota was equipped with Toyota Safety Sense P, which features five active safety technologies as discussed below.

Pre-Collision System (PCS). The PCS uses both a camera and laser radar to detect objects in front of the vehicle. If the system believes that there is the possibility of a collision, it prompts the driver to brake using audio and visual alerts. When the driver brakes to avoid the obstacle, the system provides additional braking force. If the driver fails to act, the system will automatically apply the brakes, reducing speed by approximately 19 mph in order to prevent (or reduce the severity of) a collision. PCS operates at the speeds where at least 80 percent of rear-end collisions occur, between approximately 6 and 50 mph.

Lane Departure Alert (LDA). The LDA uses a camera to detect the white and yellow lane markings on the road. If the system detects that the vehicle has started to wander out of its lane, it alerts the driver with audio and visual alerts.

Automatic High Beam (AHB). AHB uses a camera to detect oncoming vehicles' headlights, and automatically switches between low and high beam.

PCS with pedestrian detection: This function uses a millimeter-wave radar and a camera to detect pedestrians as well as vehicles.

Radar Cruise Control (RCC). RCC uses millimeter-wave radar to determine the speed of other vehicles ahead on the highway. It then adjusts the vehicle's speed until there is a safe distance between vehicles. The system uses the millimeter-wave radar as well as a forward facing camera to detect vehicles merging in and out of your lane to help maintain smooth acceleration and deceleration.

2018 TOYOTA COROLLA OCCUPANTS

Driver Demographics

Age/sex:	23 years/female
Height:	165 cm/64 in
Weight:	61 kg/134 lbs
Eyewear:	Unknown
Seat type:	Bucket
Seat track position:	Unknown, moved by police
Manual restraint usage:	Lap and shoulder used
Usage source:	Vehicle inspection

Air bags:	Frontal, knee, seat-mounted side, IC air bags. Not deployed.
Alcohol/drug data:	.246 g/dl, positive for cannabinoids (autopsy report)
Egress from vehicle:	Fatal on scene
Transport from scene:	None
Type of medical treatment:	None

Driver Injuries

Inj. No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Laceration of septum pellucidum (membrane separating anterior horns of the left and right lateral ventricles)	140688.3	Top instrument panel	Certain
2	Atlantoaxial dislocation	650206.3	Safety belt	Probable
3	Subdural hemorrhage overlying cerebral cortex, cerebellum and brainstem	140650.3	Top instrument panel	Certain
4	Subarachniod hemorrhage	140693.2	Top instrument panel	Certain
5	Liver laceration with associated 100 ml hemoperitoneum	541820.2	Safety belt	Certain
6	Bilateral inferior temporal lobe contusions, 5 mm	140621.2	Top instrument panel	Certain
7	Bilateral frontal lobe white matter punctate and streak hemorrhages	140642.2	Top instrument panel	Certain
8	Contusion, right forehead Contusion, nose	210402.1	Top instrument panel	Certain
9	Lower lip laceration - tongue and lip result of biting through the tongue and lower lip	210602.1	Top instrument panel	Certain
10	Laceration, chin 3.8 m (1.5 in)	210602.1	Top instrument panel	Probable

Inj. No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
11	Abrasion, chin	210202.1	Steering wheel rim	Probable
12	Abrasion, right side of neck	310202.1	Steering wheel rim	Possible
13	Contusion, anterior left shoulder	710402.1	Safety belt	Certain
14	Abrasions, center chest	410202.1	Safety belt/Steering wheel rim	Certain
15 16	Abrasions/contusions, left hip	810202.1 810202.1	Safety belt	Certain
17 18	Abrasions/contusions, left lower abdomen	510202.1 510402.1	Safety belt	Certain
19	Contusion, posterior left hand	710402.1	Unknown	Unknown
20	Contusion, right upper arm	710402.1	Unknown	Unknown
21	Laceration, right knee, 1.9 cm (0.75 in)	810600.1	Left instrument panel	Certain
22	Contusion, left knee	810402.1	Left instrument panel	Certain
23	Contusion, left lower leg	810402.1	Left instrument panel	Certain
24	Tongue contusion	243401.1	Top instrument panel	Probable
25	Translingual tongue laceration	243402.1	Top instrument panel	Probable

Source: Autopsy

Driver Kinematics

The 23-year-old female driver was seated in an unknown posture and was using the lap and shoulder safety belt. Just prior to impact, the driver began braking. At impact, the driver was displaced forward, loading and stretching the safety belt. The driver continued forward and engaged the steering wheel rim with her chest and loaded the lower instrument panel with her knees. She wrapped around the steering wheel and her head flexed forward, first causing the atlantoaxial dislocation and causing the brain and facial injuries as she struck the top of the instrument panel (**Figure 9**).

Figure 9. Driver steering wheel and instrument panel contacts, 2018 Toyota Corolla.

Front Row Right Passenger Demographics

Age/sex:	22 years/female
Height:	165 cm (64 in)
Weight:	60 kg (132 lbs)
Eyewear:	Unknown
Seat type:	Bucket
Seat track position:	Unknown, moved by police
Manual restraint usage:	Lap and shoulder used
Usage source:	Vehicle inspection
Air bags:	Frontal, seat-mounted side, seat cushion, and IC air bags. No deployments.
Alcohol/drug data:	BAC .25 g/dL [medical records]
Egress from vehicle:	Removed, due to serious injuries
Transport from scene:	Ambulance
Type of medical treatment:	Hospitalized for 5 days

Front Row Right Passenger Injuries

Inj. No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Minimally offset acute bilateral sacral fractures with fracture lines extending across the S3 body, narrowing of the sacral canal	856161.3	Lap belt	Probable
2	Large, complex laceration, right superior margin of the urinary bladder. CT revealed intraperitoneal bladder rupture.	540640.3	Lap belt	Probable
3	Fracture, left hand 2nd metacarpal	752000.2	Right instrument panel	Possible
4	Brief loss of consciousness, per EMS	161002.2	Right instrument panel	Certain
5	Lip laceration, uppper lip full thickness laceration, epistaxis	210602.1	Right instrument panel	Certain
6	Laceration, tip of nose	210600.1	Right instrument panel	Certain
7 8 9 10	Abrasions, right chest, abdomen, both illiac crests	410202.1 510202.1 810202.1 810202.1	Shoulder portion of restraint Lap portion of restraint	Certain Certain
11	Large forehead/frontal hematoma	210402.1	Right instrument panel	Certain
12 13	Contusions, left and right lower legs	810402.1 810402.1	Lower, right instrument panel	Probable

Source: Discharge summary, operative report, radiology reports

Front Row Right Passenger Kinematics

The 22-year-old female front right passenger was seated in an unknown posture and was using the lap and shoulder safety belt. At impact with the Ford, she was displaced forward. She loaded the safety belt with her abdomen, pelvic, and torso. Her lower legs contacted the lower instrument panel. There was payout of the safety belt as she pitched forward and contacted the top of the instrument panel with her head/face (**Figure 10**). She was extricated by EMS personnel and transported from the scene by ambulance. She was hospitalized for five days.

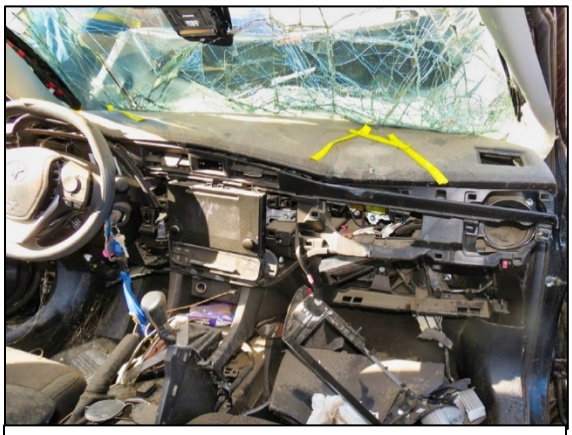


Figure 10. Right instrument panel contact, 2018 Toyota Corolla.

2017 FORD EXPEDITION

Description

The 2017 Ford Expedition was a five-door sport utility vehicle. The vehicle was identified by the VIN 1FMJU1JT9Hxxxxxx. The vehicle was equipped with a 6-cylinder, 3.5-liter, flex-fuel engine and 4-wheel drive.

Figure 11. Rear plane damage, 2017 Ford Expedition (police photo).

Exterior Damage

The Ford sustained moderate rear-plane damage from the impact with the front plane of the Toyota (**Figure 11**). The direct damage extended from bumper corner to bumper corner.

The CDC was 06BDEW3. The vehicle was towed from the scene due to damage.

Event Data Recorder

The Ford was equipped with a restraint control module (RCM) that had EDR capability to store deployment and non-deployment events. Both types of events can contain pre-crash and crash data. The EDR data was imaged by law enforcement agency. Only a PDF copy of the Bosch CDR Report was provided by law enforcement to the SCI investigator, and the hexadecimal data contained in the Bosch CDR report has been deleted due to the potential personal identifiable information contained (vehicle identification number) in the report. The Bosch CDR report is included as **Appendix B** at the end of this report. The vehicle pre-crash data is as follows:

Time (sec)	Vehicle Speed mph (km/h)	Accelerator pedal %	Service Brake, On/Off	Engine RPM	ABS Activity
-5.0	7 (11)	0.0	On	678	non-engaged
-4.5	6 (9)	0.0	On	684	non-engaged
-4.0	5 (8)	0.0	On	698	non-engaged
-3.5	4 (6)	0.0	On	778	non-engaged
-3.0	2 (4)	0.0	On	756	non-engaged
-2.5	1 (2)	0.0	On	720	non-engaged
-2.0	1 (1)	0.0	On	672	non-engaged
-1.5	0 (0)	0.0	On	674	non-engaged
-1.0	0 (0)	0.0	Off	670	non-engaged
-0.5	1 (1)	0.0	Off	710	non-engaged
0.0	1 (2)	5.1	Off	752	non-engaged

Occupant Data

There were four occupants in the Ford. The driver was a belted 39-year-old female who complained of pain to her left arm and was transported by ambulance to a local hospital. The front right seat occupant was a belted 54-year-old male who complained of pain to the lower back and a left foot sprain and was transported by ambulance to a local hospital. The second row right occupant was a belted 12-year-old male who complained of neck and back pain and was transported by ambulance to a local hospital. The third row occupant was a 13-year-old male who sustained multiple contusions and lacerations and was transported by ambulance to a local hospital.

2016 FREIGHTLINER CASCADIA 125 CBE TRACTOR
2017 CIMCR TRAILER

Description

The Freightliner was a cab-behind-engine tractor pulling a CIMCR trailer. The vehicle was identified by the VIN 3AKJGEDV7GSxxxxxx. The vehicle was equipped with a 12.8-liter, 6-cylinder, Detroit diesel engine, 6 x 4 drive, and a 125-inch sleeper.

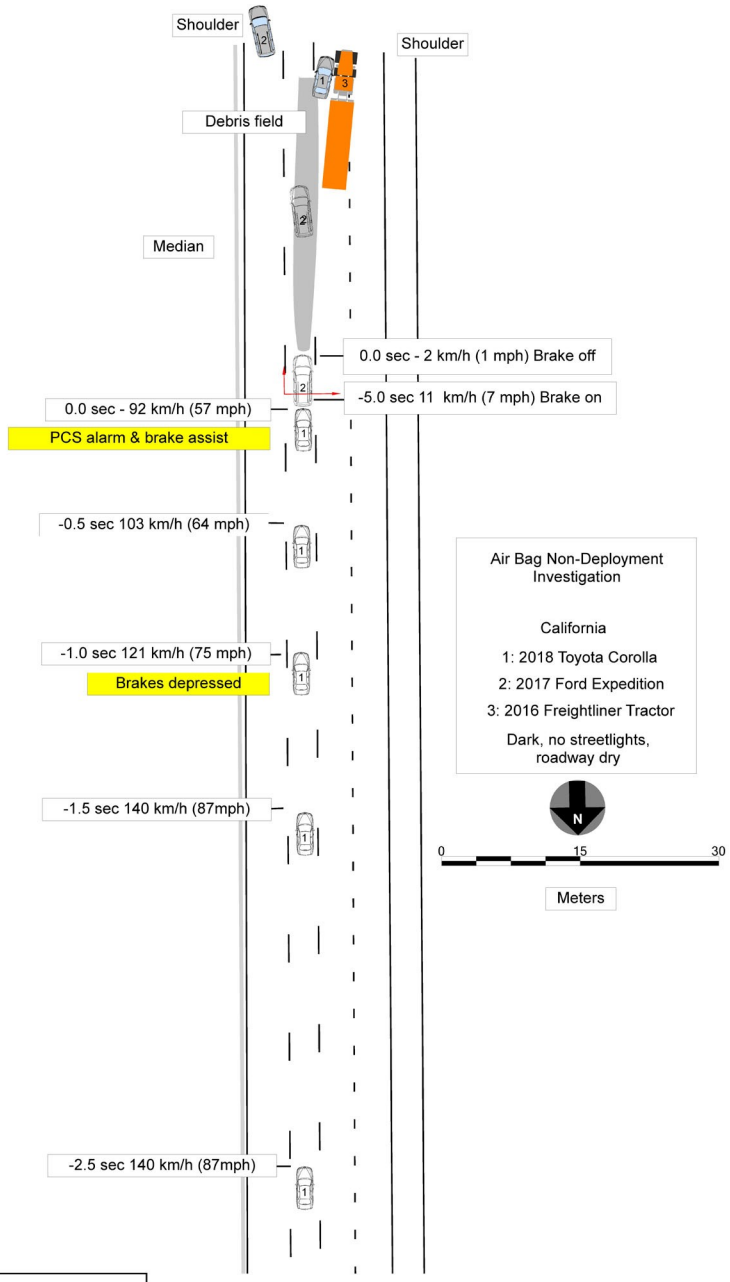
Vehicle Damage

The police reported that this vehicle sustained minor contact to the left side. The vehicle was driven from the scene.

Occupant Data

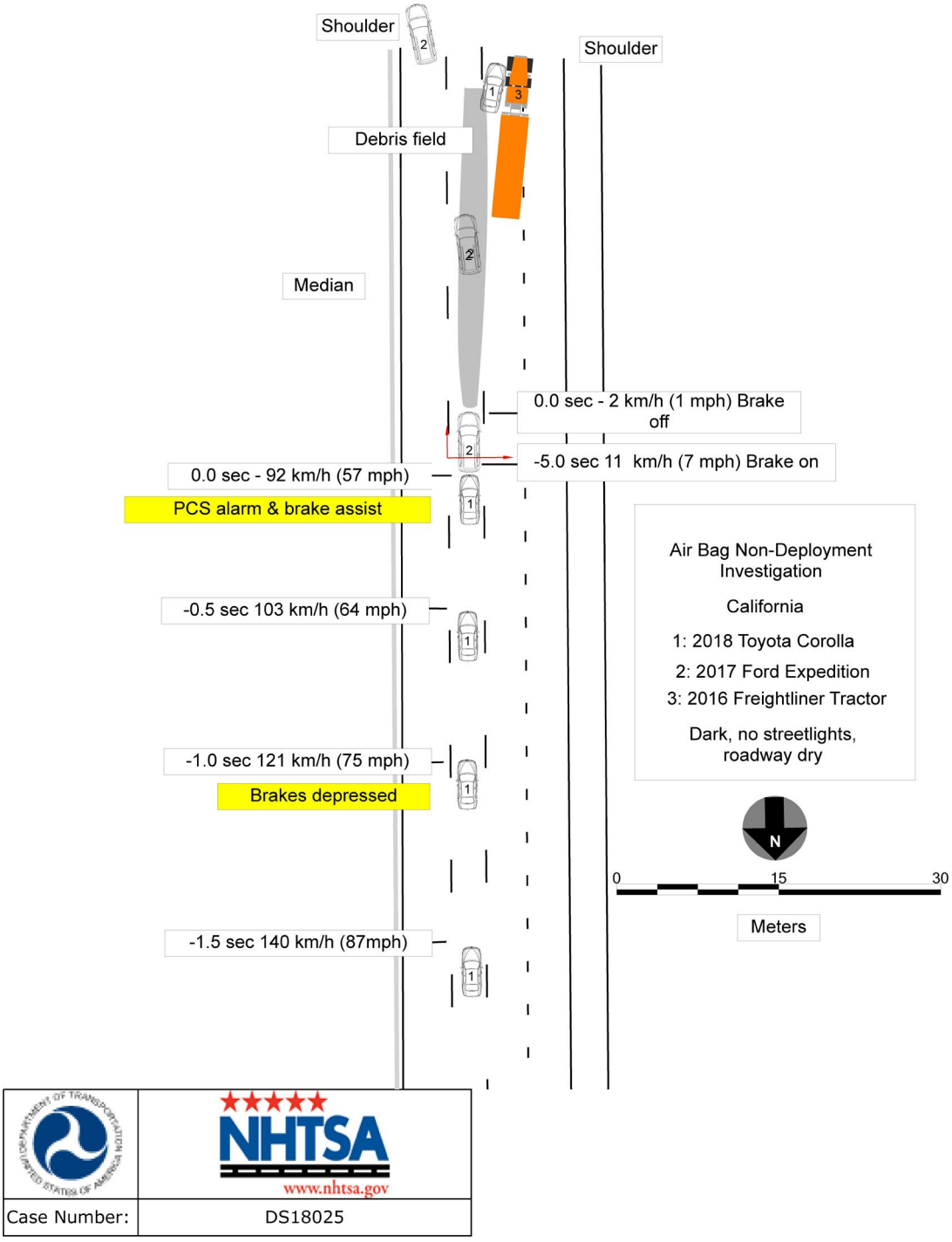
The driver of the Freightliner did not report any injuries.

CRASH DIAGRAM



	www.nhtsa.gov
Case Number:	DS18025

CRASH DIAGRAM DETAILED VIEW



APPENDIX A: EVENT DATA RECORDER (EDR) REPORT 2018 TOYOTA COROLLA[3]

[3] The Bosch CDR Report contained in this technical report was imaged by the investigating police department. Only a PDF copy of the Bosch CDR Report was provided by the police and the hexadecimal data contained in the report has been deleted due to the potential personal identifiable information contained (vehicle identification number) in the 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	5YFBURHEXJPxxxxxx
User	xx
Case Number	xx
EDR Data Imaging Date	xx
xx	xx
Filename	5YFBURHEXJPxxxxxx_ACM.CDRX
Saved on	Monday, July 9 2018 at 09:46:53
Imaged with CDR version	Crash Data Retrieval Tool 17.7.1
Imaged with Software Licensed to (Company Name)	xx
Reported with CDR version	Crash Data Retrieval Tool 17.7.1
Reported with Software Licensed to (Company Name)	xx
EDR Device Type	Airbag Control Module
Event(s) recovered	None

Comments

Surrogate/exemplar airbag ECU imaging at Inland MAIT office

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 any of the front passenger seat airbags, side airbags, or Curtain Shield Airbags have deployed, data will not be overwritten or deleted by the airbag ECU following that event. If none of the airbags have deployed, the data of that event may be overwritten by a following event even if other airbags (pretensioner, rear seat airbag, etc.) have deployed.
- 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 record pre-crash data and post-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
- In frontal and rear collision events, the first point where a longitudinal cumulative delta-V of over 0.8 km/h (0.5 mph) is reached is regarded as time zero for the recorded data. In side impact collision and rollover events, 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).
- 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.
- In frontal and rear collision events, the record time varies depending on the period during which a longitudinal cumulative delta-V of over 0.8 km/h (0.5 mph) is reached, and time series data is recorded for up to 250 ms. The record time described above is indicated as "Length of Delta-V". "Delta-V, Longitudinal" outside the record time is indicated by area shaded in the table, and not indicated in the graph.

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
Maximum Delta-V, Longitudinal	Forward
Delta-V, Longitudinal	Forward
Lateral Acceleration for Frontal/Rear Crash, Floor Sensor	Left to Right
Lateral Acceleration, Side Satellite Sensor 1	Left to Right
Lateral Acceleration, Side Satellite Sensor 2	Left to Right
Lateral Acceleration, Side Satellite Sensor 3	Left to Right
Lateral Acceleration, Side Satellite Sensor 4	Left to Right
Lateral Acceleration for Side Crash, Floor Sensor	Left to Right
Roll Angle Peak	Clockwise Rotation
Roll Angle at the Time of TRG	Clockwise Rotation
Roll Rate	Clockwise Rotation
Lateral Acceleration for Rollover, Floor Sensor	Left to Right
Longitudinal Acceleration , VSC Sensor	Forward
Yaw Rate	Left Turn
Steering Input	Left Turn

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.
- If the "Occupant Size Classification, Front Passenger" displays "Child" or "Not Occupied", "Side Air Bag Deployment, Time to Deploy" and "Pretensioner Deployment, Time to Fire" may indicate a time even if deployment did not occur on the for following part no's:
  - 89170-07280, 35400, 35410, 35470, 42660, 0R120, 0R080, 0R081, 0R150
- "Engine RPM" indicates the number of engine revolutions, not the number of motor revolutions. The recorded value has an upper limit of 12,800 rpm. Resolution is 100 rpm and the value is rounded down and recorded. For example, if the actual engine speed is 799 rpm, the recorded value will be 700 rpm.
- If the electric vehicle is using a calculated/virtual engine RPM for drivetrain control, "Engine RPM" may be recorded, but should not be used during data analysis.
- The upper limit for the recorded "Vehicle Speed" value is 200 km/h (125mph). Resolution is 1km/h (0.6mph) 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 Pedal" has two recording specifications. Both the recorded value increases as the driver depresses the accelerator.
  - Percentage of accelerator pedal depressed (recorded as 0-100(%)).
  - Output voltage of accelerator pedal module (recorded as 0-5(V)).
- If M/T transmission vehicle of some limited model, "Shift Position" may display "Drive" regardless of the actual shift position.
- Depending on the type of occupant sensor installed in the vehicle, one of the following three recording formats for "Occupant Size Classification, Front Passenger" will be utilized.
  - Occupied / Not Occupied
  - AM50 / AF05 / Child / Not Occupied
  - AM50 / AF05 / Child or Not Occupied
- "Cruise Control Status" indicates whether the cruise control system is actuated or not. OFF indicates that the cruise control system is not actuated, but can also indicates that the vehicle is not equipped with the system.
- "Air Bag Warning Lamp, On/Off", "Ignition Cycle, Crash", "Seat Track Position Switch, Foremost, Status, Driver", "Occupant Size Classification, Front Passenger", "Safety Belt Status, Driver", "Safety Belt Status, Front Passenger", "Frontal Air Bag Suppression Switch Status, Front Passenger", and "RSCA Disable Switch" indicate the state approximately 1 second before time zero. They may not always indicate the state at the moment of collision.
- The upper and lower limits for the recorded value of "Motor RPM" is 17,500 rpm and -7,500 rpm respectively. Resolution is 100 rpm and the value is rounded down and recorded.
- "Brake Oil Pressure" has an upper limit of 12.14 Mpa. In the case of the vehicle that has not VSC system, "0 Mpa" or "Invalid" may be displayed.
- "Longitudinal Acceleration , VSC Sensor" has upper and lower limits for the recorded value of 8.973 m/s^2 and -8.973 m/s^2 respectively. This acceleration sensor does not sense collisions.
- "Sequential Shift Range" displaying "Undetermined" indicates the shift range is undetermined or was not being used.

- Some vehicles will not be equipped with all "Drive Mode" types indicated in the "Drive Mode" table. If some or all drive modes are not applicable to vehicle, "OFF" or "Invalid" may be displayed. The item in the "Drive Mode" table may not match the name of switch or indicator that equipped the vehicle.
- The upper and lower limits for the recorded value of "Steering Input" is 375 deg and -375 deg respectively. Resolution is 1.5 deg and the value is rounded down and recorded.
- Resolution of the "Air Bag Warning Lamp ON Time Since DTC was Set" is 15 minutes, and the value is rounded down and recorded.
- "Delta-V, Longitudinal" indicates the change in forward speed after time zero. 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 time zero.
- "Location of Side Satellite Sensor" 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) isrecorded.
- "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 50 [ms], and the value is rounded up and recorded.
- "Roll Angle at the Time of TRG" and "Roll Angle Peak" do not represent the actual roll angle of the vehicle. These values are used internally by the airbag ECU for sensing a rollover.

05013_ToyotaS00std_r026

System Status at Time of Retrieval

ECU Part Number	89170-02K90
EDR Generation	13EDR
Complete File Recorded	Yes
Freeze Signal	OFF
Freeze Signal Factor	None
Diagnostic Trouble Codes Exist	No
Ignition Cycle ,Download (times)	1
Multi-event, number of events (times)	N/A
Time from event 1 to 2 (s)	N/A
Time from Previous Pre Crash TRG (msec)	0
Latest Pre-Crash Page	0
Contains Unlinked Pre-Crash Data	No

Event Record Summary at Retrieval

Events Recorded	TRG Count	Crash Type	Time (msec)	Pre-Crash & DTC Data Recording Status	Event & Crash Pulse Data Recording Status
None	N/A	N/A	N/A	N/A	N/A

APPENDIX B: EVENT DATA RECORDER (EDR) REPORT 2017 FORD EXPEDITION[4]

[4] The Bosch CDR Report contained in this technical report was imaged by the investigating police department. Only a PDF copy of the Bosch CDR Report was provided by the police and the hexadecimal data contained in the report has been deleted due to the potential personal identifiable information contained (vehicle identification number) in the report.

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CDR File Information

User Entered VIN	1FMJU1JT9HEXXXXXX
User	xxx
Case Number	xxx
EDR Data Imaging Date	xxx
Crash Date	xxx
Filename	1FMJU1JT9HEXXXXXX_ACM.CDRX
Saved on	xxx
Imaged with CDR version	Crash Data Retrieval Tool 17.7.1
Imaged with Software Licensed to (Company Name)	California Highway Patrol
Reported with CDR version	Crash Data Retrieval Tool 17.7.1
Reported with Software Licensed to (Company Name)	California Highway Patrol
EDR Device Type	Airbag Control Module
ACM Adapter Detected During Download	No
Event(s) recovered	Event Record 1

Comments

xxx

Data Limitations

Data Imaging:

CAUTION: When imaging data directly from the RCM on a bench top, make sure the RCM is placed on a flat surface without any movement (static) while connected to and powered by the CDR interface. Not following the above guideline for bench top imaging could risk inducing new events to be recorded in the RCM and possibly overwriting a Non airbag deployment.

Note that the RCM Adapter Detected during Download parameter equal to " Yes" indicates that the EDR data was collected directly from the RCM. When equal to "No", it indicates that the EDR data was collected through the OBD II from the vehicle.

Restraints Control Module (RCM) Recorded Crash Event(s):

The RCM can store up to two crash events. Event types are categorized as follow:

1. Non deployment trigger event is an event in which EDR recording trigger threshold is met or exceeded (minimum of 5 mph (8kph) Accumulated Delta Velocity within 150ms interval), but no device(s) have deployed. The data from such event can be overwritten by subsequent events.

2. Airbag deployment event is an event in which frontal, side or curtain airbags have deployed. Note that such event cannot be overwritten or cleared from the Restraints Control Module (RCM). Once the RCM has deployed any airbag device(s), the RCM must be replaced.

3. Some RCM may also categorize Non airbag deployment event. This type is an event in which non airbag devices such as pretentioners, knee bolster etc… have deployed. Note that such event can be overwritten given a subsequent "deployment" event.

"Time zero" or Event Beginning of any event (First Record or Second Record) is defined as the first Algorithm wake up during that event. So all the Pre-Crash, At Event, Delta V Data, deployment times etc… are relative to "Time zero".

It is possible that conditions in a crash may result in an incomplete event data record.

EDR Data Elements Overview/Interpretation in CDR Report:

Under CDR File Information Section

- Event(s) recovered indicates if an event was detected and recorded by RCM. If no event is detected, it will indicate "none". If a trigger or non airbag deployment event is detected, it will indicate "unlocked event". If an airbag deployment is detected, it will indicate "locked frontal event", or "locked side event", or "locked rollover event".

Under System Status at Event Section

- Complete file recorded indicates if data from the recorded event has been fully written to the RCM memory.
- If the RCM detected a peripheral crash sensor was lost during an event, the crash sensor would be identified as well as the time it was lost during that event relative to Time zero. If no loss of a peripheral crash sensor, nothing would be displayed. Note in some vehicles, loss of a peripheral crash sensor may lead to the loss of another peripheral crash sensor due to shared communication.

Under Deployment Data Section

- If the RCM commanded a deployment during an event, the deployment device(s) would be identified as well as the time the RCM commanded its deployment relative to Time zero. If no device was commanded to deploy by the RCM, nothing (no deployment device(s)) would be displayed.

Under Pre-Crash Data -5 to 0 sec

- Steering Wheel Angle if Applicable: positive value indicates left turn, and negative value would indicate right turn.
- Stability Control Lateral Acceleration if Applicable: Lateral Acceleration (Y-direction) is the acceleration along the lateral axis of the vehicle, reported as positive when accelerating to the left.
- Stability Control Longitudinal Acceleration if Applicable**:** Longitudinal Acceleration (X-direction) is the acceleration along the longitudinal axis of the vehicle, reported as positive when accelerating in a forward direction.
- Stability Control Yaw Rate if Applicable: The Yaw Axis is the vertical axis of the vehicle, generally perpendicular to the plane of the road. A positive Yaw Rate is counter-clockwise when observing the vehicle from above.
- Stability Control Roll Rate if Applicable: The Roll Axis is the longitudinal axis of the vehicle, generally aligned with the primary axis of motion of the vehicle. A positive Roll Rate is counter-clockwise when observing the vehicle from the front.

Under Longitudinal Crash Pulse

- Delta-V, longitudinal: SAE J211 sign convention, negative value generally indicates a front crash and positive value generally indicates a rear crash. Longitudinal delta-V reflects the change in forward velocity that the sensing system experienced from Time zero. It is not the speed the vehicle was traveling before the event. Note that the vehicle speed is recorded separately. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle longitudinal delta-V.

Under Lateral Crash Pulse

- Delta-V, lateral: SAE J211 sign convention, Positive value generally indicates a driver side crash and negative value generally indicates a passenger side crash.

Under Rollover Sensor Data (if Applicable)

- Vehicle roll angle if applicable: The Roll Axis is the longitudinal axis of the vehicle, generally aligned with the primary axis of motion of the vehicle. A positive Roll Angle is counter-clockwise when observing the vehicle from thefront.

Data Sources:

The Restraints Control Module (RCM) contains all recorded data on any event. Data collected from the RCM comes from multiple sources:

1. Internal to the RCM such as internal sensors for delta Velocity data, rollover angle data if applicable, etc… which are measured, calculated and stored internally.

2. External to the RCM but with a direct connection such as buckle switches, peripheral crash sensors, seat track switch(s) etc… which are measured, calculated and stored internally.

3. External Modules to the RCM such as Powertrain Control Module, Brake Control Module, etc… Theses modules communicate to the RCM via Vehicle Communication Network. The RCM stores the received data internally.

System Status at Time of Retrieval

VIN As Programmed into RCM at Factory	1FMJU1JT9HEXXXXXX
Current VIN from PCM	1FMJU1JT9HEXXXXXX
Ignition Cycle, Download (First Record)	3,502
Ignition Cycle, Download (Second Record)	N/A
Restraints Control Module Part Number	FL1T-14B321-BB
Restraints Control Module Serial Number	7029443230200000
Restraints Control Module Software Part Number (Version)	DG13-14C028-BA
Driver Side/Center Frontal Restraints Sensor Serial Number	00182A4F
Driver, Row 1, Side Restraint Sensor 1 Serial Number	00000032
Driver, Row 2, Side Restraint Sensor 2 Serial Number	00322900
Passenger Frontal Restraints Sensor Serial Number	00000000
Passenger, Row 1, Side Restraint Sensor 1 Serial Number	00000050
Passenger, Row 2, Side Restraint Sensor 2 Serial Number	20290000

System Status at Event (First Record)

Recording Status	Record Unlocked
Complete File Recorded (Yes, No)	Yes
Multi-Event, Number of Events	1
Time From Event 1 to 2 (msec)	N/A
Lifetime Operating Timer at Event Time Zero (sec)	4,409,740
Key-On Timer at Event Time Zero (sec)	2,030
Vehicle Voltage at Time Zero (V)	13.122
Energy Reserve Mode Entered During Event (Yes, No)	No

Faults Present at Start of Event (First Record)

No Faults Recorded

Deployment Data (First Record)

Maximum Delta-V, Longitudinal (MPH [km/h])	20.38 [32.80]
Time, Maximum Delta-V Longitudinal (msec)	89
Maximum Delta-V, Lateral (MPH [km/h])	-0.30 [-0.49]
Time, Maximum Delta-V Lateral (msec)	300
Longitudinal Delta-V Time Zero Offset (msec)	8.0 ms
Lateral Delta-V Time Zero Offset (msec)	8.0 ms
Roll Angle Time Zero Offset (msec)	48.0 ms

Pre-Crash Data -1 sec (First Record)

Ignition Cycle, Crash	3,493
Frontal Air Bag Warning Lamp, On/Off	Off
Safety Belt Status, Driver	Buckled
Seat Track Position Switch, Foremost, Status, Driver	Forward
Safety Belt Status, Front Passenger	Buckled
Brake Telltale	Off
ABS Telltale	Off
ESC/TC Telltale	Off
ESC/TC Off Telltale	Default
Powertrain Wrench Telltale	Off
Powertrain Malfunction Indicator Lamp (MIL) Telltale	Off

Pre-Crash Data -5 to 0 sec [2 samples/sec] (First Record, table 1 of 2)

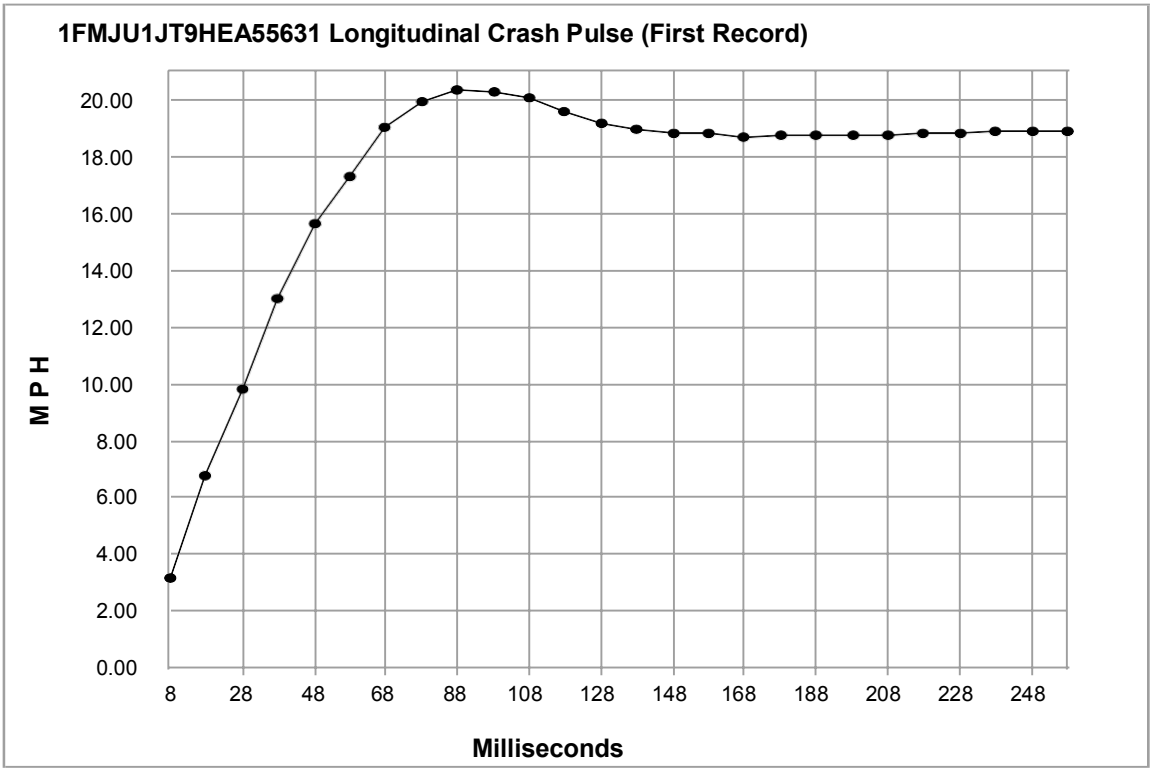
Times (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal, % Full	Service Brake, On/Off	Engine RPM	ABS Activity (Engaged, Non-Engaged)	Brake Powertrain Torque Request
- 5.0	7 [11]	0.0	On	678	non-engaged	No
- 4.5	6 [9]	0.0	On	684	non-engaged	No
- 4.0	5 [8]	0.0	On	698	non-engaged	No
- 3.5	4 [6]	0.0	On	778	non-engaged	No
- 3.0	2 [4]	0.0	On	756	non-engaged	No
- 2.5	1 [2]	0.0	On	720	non-engaged	No
- 2.0	1 [1]	0.0	On	672	non-engaged	No
- 1.5	0 [0]	0.0	On	674	non-engaged	No
- 1.0	0 [0]	0.0	Off	670	non-engaged	No
- 0.5	1 [1]	0.0	Off	710	non-engaged	No
0.0	1 [2]	5.1	Off	752	non-engaged	No

Pre-Crash Data -5 to 0 sec [2 samples/sec] (First Record, table 2 of 2)

Times (sec)	Driver Gear Selection	Traction Control via Brakes	Wheel Torque (Nm)	Speed Control Telltale
- 5.0	Drive	non-engaged	56	Off
- 4.5	Drive	non-engaged	56	Off
- 4.0	Drive	non-engaged	128	Off
- 3.5	Drive	non-engaged	164	Off
- 3.0	Drive	non-engaged	172	Off
- 2.5	Drive	non-engaged	108	Off
- 2.0	Drive	non-engaged	168	Off
- 1.5	Drive	non-engaged	224	Off
- 1.0	Drive	non-engaged	296	Off
- 0.5	Drive	non-engaged	264	Off
0.0	Drive	non-engaged	520	Off

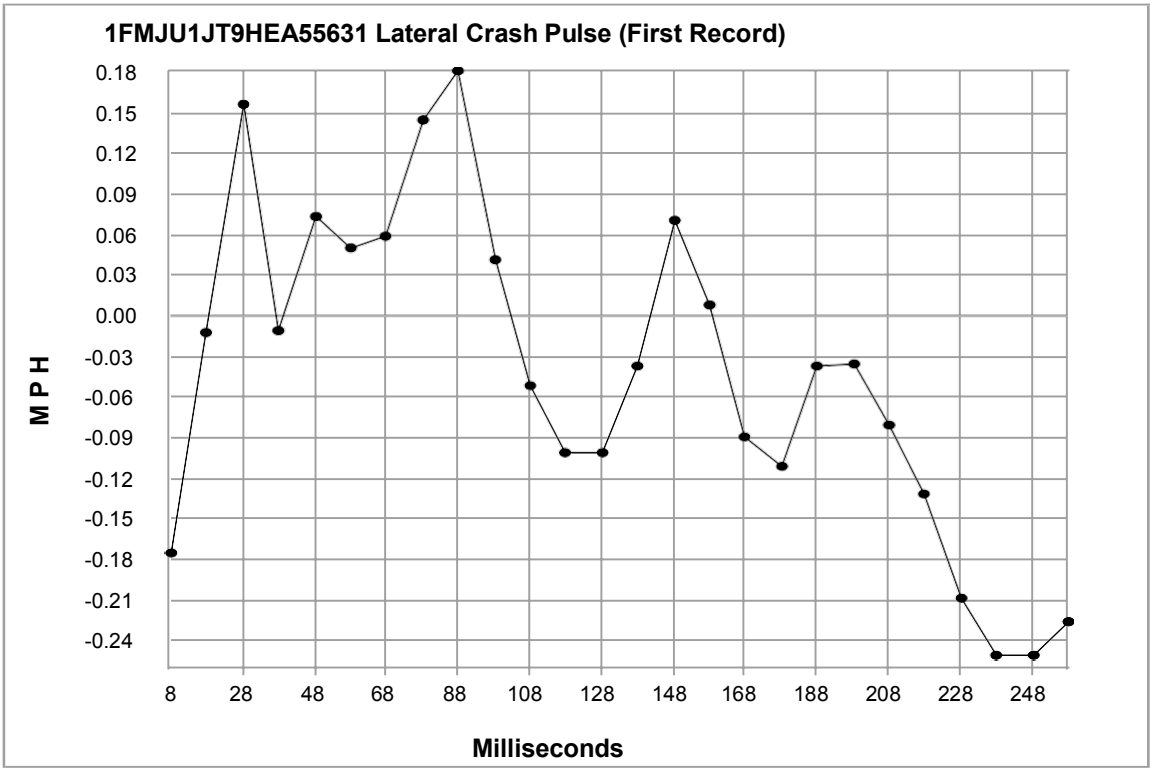
Pre-Crash Data -5 to 0 sec [10 samples/sec] (First Record)

Times (sec)	Steering Wheel Angle (degrees)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate(deg/sec)	Stability Control Roll Rate(deg/sec)
- 5.0	0.0	0.002	-0.119	-0.38	0.84
- 4.9	0.2	0.004	-0.109	-0.27	0.8
- 4.8	-0.3	0.004	-0.097	-0.22	1.08
- 4.7	0.2	0.013	-0.097	-0.36	0.56
- 4.6	0.0	0.01	-0.086	-0.45	0.92
- 4.5	0.0	-0.002	-0.093	-0.4	0.68
- 4.4	0.0	0.001	-0.09	-0.34	0.84
- 4.3	0.0	0.004	-0.093	-0.36	0.76
- 4.2	-0.3	0.002	-0.088	-0.38	0.96
- 4.1	0.0	-0.002	-0.097	-0.34	1.08
- 4.0	0.0	0.009	-0.09	-0.31	0.8
- 3.9	0.0	0.012	-0.095	-0.31	0.84
- 3.8	0.0	-0.002	-0.093	-0.27	0.88
- 3.7	-0.3	-0.008	-0.093	-0.34	0.84
- 3.6	0.0	0.004	-0.094	-0.4	1.04
- 3.5	0.2	0.007	-0.093	-0.38	1.0
- 3.4	0.0	0.004	-0.094	-0.27	0.92
- 3.3	0.0	0.0	-0.098	-0.29	0.8
- 3.2	0.0	0.002	-0.099	-0.38	0.84
- 3.1	0.0	0.003	-0.099	-0.36	0.92
- 3.0	0.0	0.0	-0.103	-0.34	1.08
- 2.9	0.0	0.005	-0.099	-0.31	0.92
- 2.8	0.2	0.008	-0.102	-0.36	0.8
- 2.7	0.0	0.004	-0.102	-0.4	0.88
- 2.6	0.0	-0.002	-0.1	-0.34	0.88
- 2.5	0.0	-0.001	-0.094	-0.36	0.92
- 2.4	0.0	0.01	-0.102	-0.4	0.96
- 2.3	0.2	0.002	-0.093	-0.4	0.88
- 2.2	0.0	0.004	-0.096	-0.38	0.8
- 2.1	0.0	0.001	-0.085	-0.34	0.88
- 2.0	0.0	0.004	-0.079	-0.34	0.84
- 1.9	0.0	0.002	-0.052	-0.38	0.88
- 1.8	0.0	0.005	-0.023	-0.45	0.8
- 1.7	0.0	0.004	0.007	-0.4	0.76
- 1.6	0.0	0.003	0.029	-0.4	0.84
- 1.5	0.0	0.004	0.042	-0.38	0.88
- 1.4	0.0	0.004	0.043	-0.36	0.96
- 1.3	0.0	0.002	0.041	-0.29	0.92
- 1.2	0.0	0.004	0.039	-0.4	0.88
- 1.1	0.0	0.002	0.041	-0.43	0.84
- 1.0	0.0	0.004	0.04	-0.38	0.92
- 0.9	0.0	0.004	0.041	-0.31	0.88
- 0.8	0.0	0.005	0.044	-0.31	0.84
- 0.7	0.0	0.003	0.047	-0.34	0.92
- 0.6	0.0	0.004	0.05	-0.4	0.88
- 0.5	0.0	0.001	0.053	-0.38	0.88
- 0.4	0.2	0.003	0.05	-0.34	1.04
- 0.3	0.0	0.004	0.053	-0.4	0.84
- 0.2	0.0	0.006	0.051	-0.43	0.92
- 0.1	0.0	0.002	0.054	-0.4	0.8
0.0	0.0	0.001	0.063	-0.31	0.8



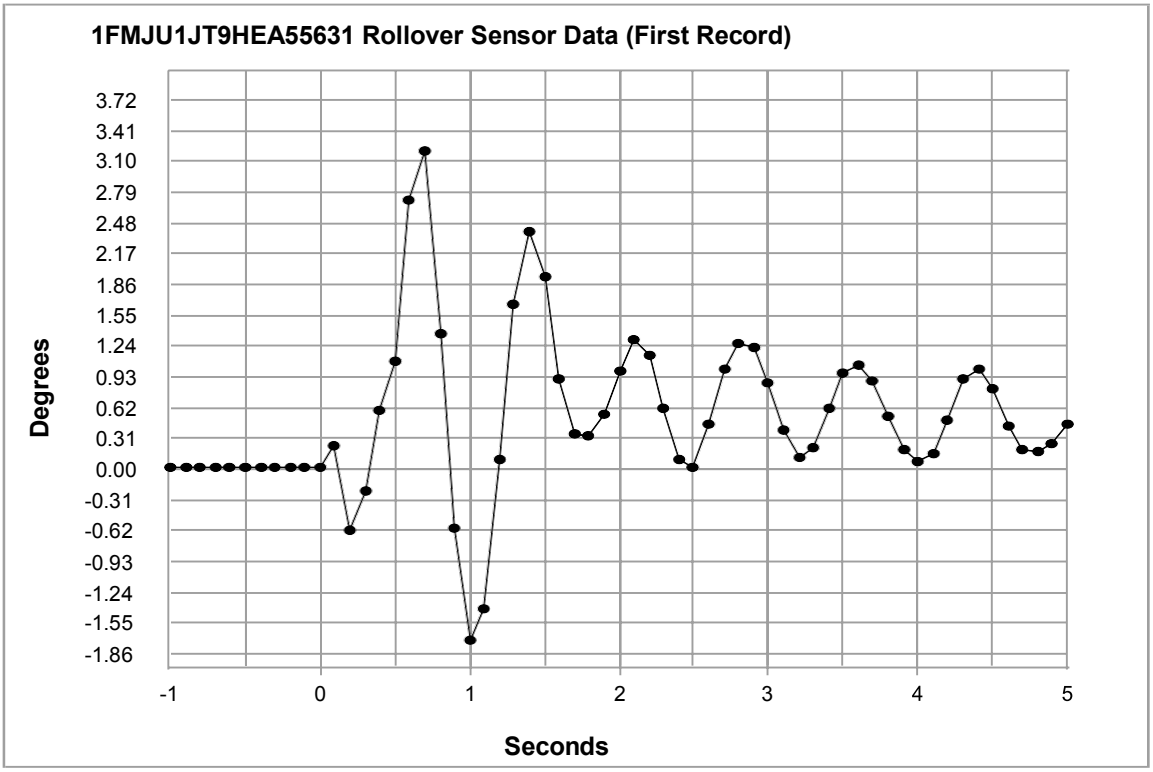
Longitudinal Crash Pulse (First Record)

Time (msec)	Delta-V, longitudinal (MPH)	Delta-V, longitudinal (km/h)
8.0	3.16	5.08
18.0	6.80	10.94
28.0	9.82	15.80
38.0	13.05	21.00
48.0	15.68	25.24
58.0	17.33	27.89
68.0	19.03	30.62
78.0	19.96	32.12
88.0	20.36	32.77
98.0	20.27	32.63
108.0	20.12	32.38
118.0	19.65	31.62
128.0	19.19	30.88
138.0	18.98	30.55
148.0	18.88	30.39
158.0	18.87	30.37
168.0	18.70	30.09
178.0	18.76	30.20
188.0	18.80	30.26
198.0	18.81	30.28
208.0	18.81	30.27
218.0	18.82	30.30
228.0	18.87	30.36
238.0	18.91	30.44
248.0	18.91	30.43
258.0	18.91	30.43



Lateral Crash Pulse (First Record)

Time (msec)	Delta-V, lateral (MPH)	Delta-V, lateral (km/h)
8.0	-0.18	-0.28
18.0	-0.01	-0.02
28.0	0.16	0.25
38.0	-0.01	-0.02
48.0	0.07	0.12
58.0	0.05	0.08
68.0	0.06	0.09
78.0	0.14	0.23
88.0	0.18	0.29
98.0	0.04	0.07
108.0	-0.05	-0.08
118.0	-0.10	-0.16
128.0	-0.10	-0.16
138.0	-0.04	-0.06
148.0	0.07	0.11
158.0	0.01	0.01
168.0	-0.09	-0.14
178.0	-0.11	-0.18
188.0	-0.04	-0.06
198.0	-0.04	-0.06
208.0	-0.08	-0.13
218.0	-0.13	-0.21
228.0	-0.21	-0.34
238.0	-0.25	-0.40
248.0	-0.25	-0.40
258.0	-0.23	-0.37



Rollover Sensor Data (First Record)

Time (sec)	Vehicle Roll Angle (deg)
-1.0	0.02
-0.9	0.02
-0.8	0.02
-0.7	0.02
-0.6	0.02
-0.5	0.02
-0.4	0.02
-0.3	0.02
-0.2	0.02
-0.1	0.02
0.0	0.02
0.1	0.24
0.2	-0.62
0.3	-0.22
0.4	0.6
0.5	1.08
0.6	2.7
0.7	3.2
0.8	1.37
0.9	-0.6
1.0	-1.73

Time (sec)	Vehicle Roll Angle (deg)
1.1	-1.4
1.2	0.11
1.3	1.66
1.4	2.4
1.5	1.94
1.6	0.91
1.7	0.35
1.8	0.33
1.9	0.56
2.0	0.99
2.1	1.31
2.2	1.15
2.3	0.62
2.4	0.11
2.5	0.02
2.6	0.46
2.7	1.01
2.8	1.27
2.9	1.23
3.0	0.86
3.1	0.4

Time (sec)	Vehicle Roll Angle (deg)
3.2	0.12
3.3	0.21
3.4	0.62
3.5	0.97
3.6	1.06
3.7	0.89
3.8	0.53
3.9	0.2
4.0	0.08
4.1	0.15
4.2	0.5
4.3	0.9
4.4	1.01
4.5	0.82
4.6	0.44
4.7	0.19
4.8	0.17
4.9	0.26
5.0	0.45

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U.S. Department
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**National Highway
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