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Special Crash Investigations Remote Child Restraint System Investigation Vehicle: 2007 Lexus GX470 Location: Colorado Crash Date: September 2016

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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 vehicles 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.

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This report documents the remote investigation of the child restraint system used by the 2-year-old female occupant of a 2007 Lexus GX470 and the injuries she sustained in a single-vehicle rollover crash.

16. Abstract

The crash occurred in the evening of September 2016 in the southbound lanes of a north/south interstate highway in Colorado. Conditions at the time of the crash were dark without illumination, partly cloudy, and dry. The Lexus was being driven southbound by an unbelted 34-year-old male. An unbelted 30-year-old female occupant was seated in the front right position and the 2-year-old female occupant was seated in the second row left position. The child was restrained in a forward-facing Safety 1st Alpha Omega Elite convertible safety seat. For unknown reasons, the Lexus departed the roadway on the right edge, overturned, and came to rest on its left side. Police indicated the Lexus rolled over seven quarter-turns. The 2-year-old female occupant sustained police reported "C" (complaint of pain/minor) injuries and was transported by ambulance to a local hospital, where she was treated and released. Both unbelted adult occupants were fully ejected and sustained "K" (fatal) injuries. They were declared deceased on-scene. The Lexus was towed due to damage and placed on a police hold. It was later released and destroyed.

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Special Crash Investigations
Remote Child Restraint System Investigation
Case Number DS16024
Vehicle: 2007 Lexus GX470
Location: Colorado
Crash Date: September 2016

BACKGROUND

This report documents the remote investigation of the child restraint system (CRS) used by the 2-year-old female occupant of a 2007 Lexus GX470 and the injuries she sustained in a single-vehicle rollover crash (**Figure 1**). The two unbelted adult occupants in the vehicle were fully ejected and sustained fatal injuries. The child was transported to a local hospital following the crash. This crash was identified by the Special Crash Investigations (SCI) group of the National Highway Traffic Safety Administration, which requested additional information from the SCI team in September 2016. The police report and images were requested and when they were obtained in November 2016 it was learned the vehicle had been released and destroyed. The case was assigned as a remote investigation.

Figure 1: 2007 Lexus GX470 (police image).

The Lexus was supported by the Bosch Crash Data Retrieval (CDR) system and the vehicle's event data recorder (EDR) was imaged by police during their investigation. Police provided SCI with a PDF copy of the complete EDR report, which is included in this report as an attachment.

The crash occurred in the evening of September 2016 in the southbound lanes of a north/south interstate highway in Colorado. Conditions at the time of the crash were dark without illumination, partly cloudy, and dry. The Lexus was being driven southbound by an unbelted 34-year-old male. An unbelted 30-year-old female occupant was seated in the front right position and the 2-year-old female occupant was seated in the second row left position. The child was restrained in a forward-facing orientation in a Safety 1st Alpha Omega Elite convertible safety seat. For unknown reasons, the Lexus departed the roadway on the right edge, overturned on the roadside and came to rest on its left side. Police indicated the Lexus rolled over seven quarter-turns. The 2-year-old female occupant sustained police reported "C" (complaint of pain/minor) injuries and was transported by ambulance to a local hospital where she was treated and released. Both unbelted adult occupants were fully ejected and sustained "K" (fatal) injuries.

They were declared deceased on-scene. The Lexus was towed due to damage and placed on a police hold. It was later released and destroyed.

SUMMARY

Crash Site

Figure 2: Crash site looking south (online image).

The crash occurred on a divided north/south interstate highway in Colorado (**Figure 2**). Crash site data including roadway measurements were obtained from the police report and satellite images. The roadway was asphalt surfaced and was configured with two southbound lanes each measuring 3.7 m (12.0 ft) wide. This roadway was straight and level. It was configured with paved shoulders on the left and right edges. The left shoulder measured 1.0 m (3.0 ft) wide and included a rumble strip. The right shoulder measured 3.0 m (10.0 ft) wide and also included a rumble strip. The travel lanes were separated by a dashed white painted stripe, the left edge was bordered by a solid yellow painted stripe, and the right edge was bordered by a solid white painted fog line. The roadside sloped slightly downward and away from the roadway and consisted of unpaved ground and desert vegetation. The posted speed limit was 121 km/h (75 mph). The investigating police officer noted no unusual conditions present at the time of the crash.

Conditions at the time of the crash as reported by the nearest weather station were temperature 17.0 degrees C (62.6 degrees F), 39 percent humidity, northeast winds at 7.4 km/h (4.6 mph), 16.0 km (10.0 mi) visibility, and partly cloudy skies. A crash diagram is included at the end of this report.

Pre-Crash

The Lexus was traveling southbound in the second lane from the right. For unknown reasons, the driver of the Lexus steered right, crossing the southbound lanes and departing the roadway on the right edge. Police used scene evidence including tire marks on the pavement to document this segment of the pre-crash trajectory, which measured 51.6 m (169.4 ft) long. After departing the roadway, the driver overcorrected his steering to the left, causing the Lexus to initiate a counterclockwise rotation and a right side leading yaw. The vehicle traveled across the shoulder for 8.8 m (29.0 ft). Police used tire furrow marks in the ground to document this segment of the pre-crash trajectory, which measured 31.6 m (104.0 ft) long. While traveling off-road the Lexus' right side tires engaged the ground with sufficient opposing lateral force to cause a right-side-leading trip rollover. The calculated speed loss was 101.0 km/h (63.0 mph).[1]

Crash

The Lexus rolled right side leading for a total of seven quarter-turns and came to rest on its left side facing east on the roadside. During the rollover, the vehicle's left and right inflatable curtain (IC) air bags deployed at an EDR-reported time of 89 milliseconds (ms) after algorithm enable (AE). Police determined the roll distance was 41.4 m (135.9 ft) long based on scene evidence

[1] Using combined speed for distance traveled while rotating and rolling.

and the final rest location of the Lexus. During the rollover, the unbelted driver and front right occupant of the Lexus were completely ejected from the vehicle. Police indicated the ejection paths for both occupants were through side windows. Images of the vehicle indicate both front row side windows were disintegrated during the crash, resulting in integrity loss on the left and right planes. The 2-year-old female occupant seated in the second row remained in place in the CRS by the 5-point harness throughout the rollover.

Post-Crash

Following the rollover, the Lexus came to rest on its left side facing east (**Figure 3**). Three witnesses traveling in a non-contact vehicle were the first to respond to the crash and give assistance. They arrived immediately following the crash and called 911. While waiting for responders, the witnesses stayed in contact with the 2-year-old female occupant of the Lexus. The fire department arrived approximately 5 minutes after the crash and police arrived approximately 12 minutes after the crash. Responders removed the child occupant from the CRS and vehicle and transported her by ambulance to a local hospital, where she was treated for minor injuries and released. The driver and front right occupant were declared deceased on-scene and transported to a local morgue. The Lexus was towed due to damage and placed on a police hold pending vehicle inspection and imaging of the EDR. The vehicle was later released and salvaged. The insurance company indicated they gave approval for the vehicle to be destroyed.

Figure 3: Final rest orientation looking west, 2007 Lexus GX470 (police image).

2007 LEXUS GX470

Description

The 2007 Lexus GX470 was identified by police using the Vehicle Identification Number JTJBT20X170xxxxxx. The vehicle was configured with an electronic odometer and the mileage is unknown. The Lexus was a 4-door sport utility vehicle (SUV) configured with an 8-cylinder, 4.7 liter, gasoline engine, automatic transmission, all-wheel drive, hydraulic brakes, antilock braking system (ABS), tilt steering, power moon roof, and an original equipment manufacturer (OEM) roof rack. The vehicle manufacturer's recommended tire size was P265/65R17 with a recommended cold tire pressure of 207 kPa (30 psi) for the front and rear. The vehicle was equipped with Michelin Latitude tires of the recommended size. Specific tire data obtained from the police report was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	6 mm (8/32 in)	No	De-beaded
LR	Unknown	6 mm (8/32 in)	No	None
RR	Tire flat	6 mm (8/32 in)	No	De-beaded
RF	Tire flat	6 mm (8/32 in)	No	De-beaded

The Lexus' interior was equipped with three rows of seating to accommodate eight occupants. The front row was configured with two bucket seats with adjustable head restraints. The seat track settings for the front row occupants was unknown. The second row was configured with 60/40 split bench seat with folding backs and adjustable head restraints. This row was configured with Lower Anchors and Tethers for CHildren (LATCH). Lower anchors were present at the left and right seat positions and tether anchors were present at all three seat positions. The third row consisted of two inboard-facing jump seats with folding seat cushions and back, and no head restraints.

Exterior Damage

Exterior images of the Lexus taken by police were used to conduct a partial exterior vehicle inspection. The Lexus sustained direct contact damage to the left, top and right planes during the rollover. Direct damage to the top plane appeared in the images to extend laterally from roof side rail to roof side rail and longitudinally from the leading edge of the hood to the backlight header. Three tires were flattened and de-beaded. The front bumper fascia was fractured and displaced, and the rear bumper fascia was fractured. The vehicle sustained crush to the top plane during the rollover. The maximum vertical crush was located on the roof and backlight header above the rear cargo area. The maximum lateral crush was located at the upper aspect of the right D-pillar (**Figure 4**). The estimated Collision Deformation Classification (CDC) for the Lexus in Event 1 was 00TDDO4.

Figure 4: Maximum vertical and lateral crush areas, 2007 Lexus GX470 (police image).

Event Data Recorder

The Lexus' EDR was imaged by police during their vehicle inspection using the Direct-to-Module method with power supplied by a portable power pack/jump box. Bosch CDR Tool version 17.0 was used to image the data, which was also reported using version 17.0 because the raw file (CDRx) was not provided. Police provided SCI with a PDF copy of the report. The Lexus' complete EDR report is included in this report as an attachment and is summarized on the following page.

The EDR was configured to record data for all or some of the following crash types: front crash, rear crash, side crash, and rollover events. Depending on the installed air bag electronic control unit (ECU), data for side crash and/or rollover events may not be recorded. The ECU may or may not record post-crash data in the event of a side crash or rollover. If applicable, the ECU has one recording page for rollover events.

For the rollover event in this crash, the Lexus' EDR indicated a rollover event occurred but that type of event was not supported. The recording status at the time of data retrieval was complete. No diagnostic trouble codes (DTCs) existed at the time of the crash. Pre-crash data was not available. The report included post-crash data consisting of graphs and tables indicating counts, roll angle and lateral acceleration. Maximum recorded roll angle peak was 106 degrees and maximum recorded lateral acceleration was 15.3 m/sec^2. The Lexus deployed the left and right IC air bags during the rollover. The EDR indicated the time of deployment for the IC air bags was 89 ms.

NHTSA Recalls and Investigations

There were no open recalls for this vehicle.

Interior Damage

The Lexus sustained interior damage caused during rollover event including fractures to the windshield, disintegration of side glass on the left and right planes, and disintegration of the backlight. Damage to glazing resulted in loss of integrity to the left, right and back planes. The police report indicated the moon roof was intact upon EMS arrival and was broken by first responders to gain access to the child occupant. The windshield was partially torn away from its original position by first responders during post-crash activities. Additional interior damage was caused by air bag deployments. Intrusion into the occupant compartment was most pronounced in the rearward aspect and third seating row.

Manual Restraint Systems

The Lexus' interior was equipped with seating for eight occupants and all seats were configured with three-point lap and shoulder belts. The front and second rows were configured for forward-facing seats and the third row was equipped for inboard-facing seats. The front row belts were equipped with retractor pretensioners, sliding latch plates and adjustable D-rings. The driver's belt was configured with an emergency locking retractor (ELR) and the front right occupant's belt was configured with an ELR/automatic locking retractor (ALR). Police stated the front row belts revealed no indication of being used at the time of the crash and the front row occupants' complete ejections supported that conclusion. The front row pretensioners did not actuate.

The second row seat belts were equipped with ELR/ALR and sliding latch plates. The left and right position belts were configured with non-adjustable D-rings and the center belt was configured with an integrated retractor. The second row was configured with Lower Anchors and Tethers for CHildren (LATCH). Lower anchors were present at the left and right seat positions and tether anchors were present at all three seat positions. The 2-year-old female occupant was seated in the second row left position. The police report indicated the lap and shoulder seat belt in that position was used to install the forward-facing CRS. Photos showed the tether anchor at

the second row left seat position was used to secure the CRS.

Supplemental Restraint Systems

The Lexus' supplemental restraint systems (SRS) included frontal air bags with dual stage inflators for the front row, and combination side-impact/roll-sensing IC air bags for all three rows. During the rollover, the left and right IC air bags deployed. The vehicle's EDR indicated a deployment time of 89 ms for both IC air bags.

Figure 5: Deployed left IC air bag, 2007 Lexus GX470 (police image).

The right IC air bag deployed from the roof side rails above the front, second and third rows. The left IC air bag deployed above the front and second row but appears to not have deployed completely above the third row (**Figure 5**).

The IC air bags were configured with tethers at the forward aspect. In their deflated state, the IC air bags appeared to have fully covered the second row side windows and covered the majority of the front row windows for the front row with the exception of a small triangle of exposure at the forward aspect. Coverage for the third row side glass was not determined. Police images of the deployed IC air bags did not reveal any damage.

Child Restraint Systems

Safety 1st Alpha Omega Elite (grey)

The Safety *1st* Alpha Omega Elite CRS was a convertible safety seat (**Figure 6**). Data for this CRS and its installation was obtained from the police report and images. Specifications were obtained from the owner's manual. The Model Number, date of manufacture and history of the CRS is unknown.

Figure 6: Safety *1st* Alpha Omega CRS (police image).

According to the owner's manual, the Safety *1st* Alpha Omega is a convertible CRS designed to be used rear-facing or forward-facing with the five-point harness, or forward-facing as a belt positioning booster seat in combination with the vehicle's lap and shoulder seat belt. It was configured with a height-adjustable headrest, height-adjustable shoulder straps for the five-point harness system, recline lever, non-removable base, shoulder belt positioning guides, rotating armrests and LATCH.

At the time of the crash, the CRS was installed in a forward-facing orientation in the second row left position using the vehicle's lap and shoulder seat belt routed through the forward-facing belt path (**Figure 7**) and with the LATCH system upper tether strap routed over the seat back and attached to the anchor located on the seat back (**Figure 8**). The police report indicated the CRS was properly installed. The manual indicates it is proper to use the upper tether in combination with the lap and shoulder belt to install this CRS.

Figure 7: Lap and shoulder seat belt used to install Safety *1st* CRS, 2007 Lexus GX470 (police image).

Figure 8: CRS tether strap to anchor connection, 2007 Lexus GX470 (police image).

The occupant parameters for using the seat with the harness system in a forward-facing orientation are as follows:

Weight:	22.0-50.0 lb (10.1-22.6 kg)
Height:	34.0-45.0 in (85.1-114.3 cm)
Age:	Over one year old

The 2-year-old female child using the CRS met the age parameter. It is unknown whether she met the height and weight parameters.

Rollover Mitigation

The Lexus was configured with several driver assist features intended to improve traction and stability including all-wheel drive, ABS, brake assist (BA), vehicle stability control (VSC),active traction control and limited slip differential. Most of these technologies rely on brake input by the driver to initiate their actuation. It is unknown whether the driver of the Lexus was actively braking prior to the rollover. The vehicle initiated a counterclockwise yaw at a high speed that precluded the vehicle's tires from tracking in a forward trajectory, negating much of the stability control functionality.

Rollover ratings for the Lexus are unknown. The vehicle owner's manual states that utility vehicles of this type have a relatively higher center of gravity and a higher rollover rate than other types of vehicles. Additionally, the manual states that sharp turns at excessive speeds may cause rollover. The police indicated in their report that, after departing the roadway at highway speed, the driver of the Lexus over-corrected his steering to the left. This situation seems to

mirror the higher risk of rollover as suggested in the owner's manual. Adding to the likelihood for rollover were the Lexus' right side tires furrowing into the unpaved ground during the right-side leading yaw. Once the Lexus had rotated sufficiently counterclockwise, the vehicle's right side tires contacted the ground with sufficient opposing lateral force as to induce a trip rollover. The vehicle was traveling on a descending embankment and at a sufficiently high speed to cause a rollover that, according to police, continued for seven quarter-turns over a distance of approximately 41.4 m (135.9 ft).

The investigation determined a combination of factors caused the Lexus to overturn, including traveling at speeds too fast for conditions, a sudden change in surfaces from asphalt to soft ground, a sharp left steering input, rotational forces, traveling on descending non-level ground, and the tires furrowing into the ground.

2007 LEXUS GX470 OCCUPANTS

Driver Demographics

Age/Sex:	34 years/male
Height:	178 cm (70 in)
Weight:	104 kg (229 lb)
Eyewear:	Unknown
Seat type:	Bucket seat with adjustable head restraint
Seat track position:	Unknown
Manual restraint usage:	Lap and shoulder seat belt not used
Usage source:	Police report
Air bag:	IC air bag deployed, frontal air bag and seat-mounted side air bags not deployed
Alcohol/drug data:	.009 g/dL BAC
Egress from vehicle:	Fully ejected through side window
Transport from scene:	To morgue
Type of medical treatment:	None

Driver Injuries

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Multiple cortical contusions, inferior cerebrum	140640.4	Ground	Probable
2	Subdural hemorrhages NFS, cerebrum	140650.3	Ground	Probable
3	Multiple comminuted fractures, occipital skull, right and middle anterior	150404.3	Ground	Probable
4	Fractures, ribs R3-R10, L3-L5	450203.3	Ground	Probable

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
5	Contusions NFS, bilateral lungs	441410.3	Ground	Probable
6	Fracture, pelvis, pubic symphysis	856161.3	Ground	Probable
7	Subarachnoid hemorrhages NFS, cerebrum	140693.2	Ground	Probable
8	Subgaleal hemorrhages NFS, scalp	110403.2	Ground	Probable
9	Fracture, medial right clavicle	750621.2	Ground	Probable
10	Lacerations NFS, spleen	544220.2	Ground	Probable
11	Multiple lacerations, minor, scalp, bilateral	110602.1	Ground	Probable
12	Multiple abrasions, scalp	110202.1	Ground	Probable
13 14	Abrasions and contusions, posterior left shoulder	710202.1 710402.1	Ground	Probable
15 16	Abrasions and contusions, back	410202.1 410402.1	Ground	Probable
17 18	Contusions, bilateral forearms	710402.1 710402.1	Ground	Probable
19	Abrasions, left thigh	810202.1	Ground	Probable
20 21	Abrasions and contusions, bilateral lower legs and feet	810202.1 810402.1	Ground	Probable

Source: Autopsy

Driver Kinematics

The unbelted 34-year-old male driver of the Lexus was seated in an unknown posture and was operating the vehicle at highway speed. For unknown reasons the driver allowed the vehicle to travel across the lanes and departed the roadway on the right edge. He actively steered left overcorrecting and causing the vehicle to initiate a counterclockwise rotation and right side leading yaw. The vehicle tripped right side leading and the driver was displaced to the right in response to the direction of the rollover. The left IC air bag deployed in the Lexus, covering the side glass. The driver was displaced to the right from his seated position and possibly contacted the front right occupant. The vehicle continued to roll right along its horizontal axis for a total of seven quarter-turns during which time the unbelted driver was displaced in the front row of the occupant compartment. At some point during the rollover the driver was fully ejected through the front row left side window and came to rest 13.9 m (45.7 ft) south of the vehicle.

The driver sustained external and interior injuries ranging in severity from minor to severe including contusions and hemorrhages to the cerebrum, fractures to the skull, fractures to the bilateral ribs, contusions to the bilateral lungs, hemorrhages to the scalp, fracture to the clavicle, lacerations to the spleen, lacerations and abrasions to the scalp, and abrasions and contusions to the trunk, upper extremities and lower extremities. The primary source of the driver's injuries was probably contact with the ground.

Front Row Right Occupant Demographics

Age/Sex:	30 years/female
Height:	168 cm (66 in)
Weight:	87 kg (192 lb)
Eyewear:	Unknown
Seat type:	Bucket seat with adjustable head restraint
Seat track position:	Unknown
Manual restraint usage:	Lap and shoulder seat belt not used
Usage source:	Police report
Air bag:	IC air bag deployed, frontal air bag and seat-mounted side air bags not deployed
Alcohol/drug data:	.025 g/dL BAC
Egress from vehicle:	Fully ejected through side window
Transport from scene:	To morgue
Type of medical treatment:	None

Front Row Right Occupant Injuries

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Subdural hemorrhages NFS, cerebrum	140650.3	Ground	Probable
2	Contusions NFS, bilateral lungs	441410.3	Ground	Probable
3	Fractures, ribs, L3-L6	450203.3	Ground	Probable
4	Hemothorax, left lung (125 ml) and hemoperitoneum, left (150 ml)	442200.3	Ground	Probable
5	Subarachnoid hemorrhages NFS, cerebrum	140693.2	Ground	Probable
6	Subgaleal hemorrhages NFS, scalp	110403.2	Ground	Probable
7	Fracture, hyoid bone	350200.2	Ground	Probable
8	Transverse process fracture, vertebra C5	650220.1	Ground	Probable

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
9	Lacerations NFS (3.5 cm/1.4 in), spleen	544220.2	Ground	Probable
10	Fracture, mid-shaft, left humerus	751251.2	Ground	Probable
11 12	Abrasions and contusions, face, right forehead, eyelid and cheek	210202.1 210402.1	Ground	Probable
13	Abrasion, right forearm	710202.1	Ground	Probable
14	Contusions, left elbow and hand	710402.1	Ground	Probable
15	Abrasions, left buttock	810202.1	Ground	Probable

Source: Autopsy

Front Row Right Occupant Kinematics

The unbelted 30-year-old female front right occupant of the Lexus was seated in an unknown posture. Initially, the vehicle traveled to the right across the lanes and departed the roadway on the right edge. Over corrective steering to the left caused the vehicle to initiate a counter-clockwise rotation and right side leading yaw. The occupant was displaced to the right in response to the rotational forces and likely contacted the right door panel, which mitigated further movement. The vehicle tripped right side leading and the occupant was displaced again to the right in response to the direction of the rollover. The right IC air bag deployed in the Lexus covering the side glass. The occupant was displaced to the right from her seated position and likely contacted the deployed IC air bag and side glass. She was possibly contacted by the unbelted driver who was displaced from his seated position. The vehicle continued to roll right along its horizontal axis for a total of seven quarter-turns during which time the unbelted occupant was displaced in the front row of the occupant compartment. At some point during the rollover the occupant was fully ejected through the front row right side window and came to rest 4.8 m (15.9 ft) north of the vehicle.

The occupant sustained external and interior injuries ranging in severity from minor to serious including hemorrhages to the cerebrum, contusions to the bilateral lungs, fractures to the left ribs, hemorrhages to the scalp, fracture to the hyoid bone, fracture to the cervical vertebra, lacerations to the spleen, fracture to the left humerus, abrasions and contusions to the face, and abrasions and contusions to the upper and lower extremities. The primary source of the occupant’s injuries was probably contact with the ground.

Second Row Left Occupant Demographics

Age/Sex:	2 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	None
Seat type:	Split bench with folding back and adjustable head restraint
Seat track position:	NA
Manual restraint usage:	Forward-facing CRS with 5-point harness system
Usage source:	Police report and images
Air bags:	IC air bag deployed
Egress from vehicle:	Removed due to age
Transport from scene:	Ambulance to hospital
Type of medical treatment:	Treated and released

Second Row Left Occupant Injuries

Inj. No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Laceration, minor (1.5 cm), right foot	810602.1	Flying glass	Possible
2	Abrasion, left foot	810201.1	Flying glass	Possible

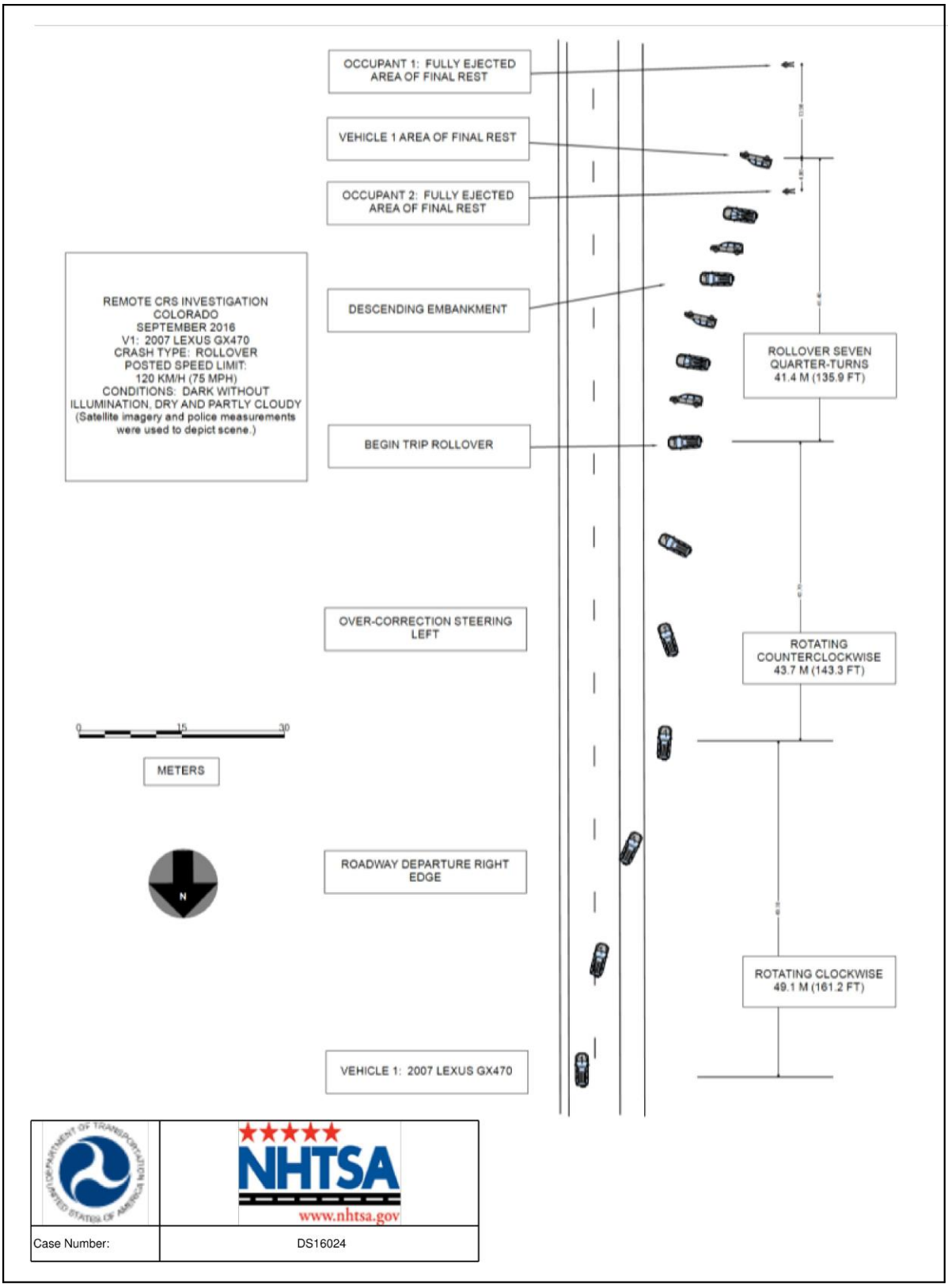
Source: Medical records

Second Row Left Occupant Kinematics

The CRS-restrained 2-year-old female was seated in a forward-facing orientation and an upright posture. She was restrained using the CRS five-point harness system. The vehicle departed the roadway and initiated a counterclockwise rotation and right side leading yaw. This occupant was displaced to the right and remained held in place in the CRS by the harness. During the initial trip and first quarter-turn of the rollover, the occupant was displaced further to the right and remained in place. The vehicle's left IC air bag deployed adjacent the occupant's seat position. Nothing in the police report or medical records suggested there was contact between the occupant and the deployed air bag. The police report and images indicated the CRS was properly installed in the vehicle and it appeared to have remained in place on the bench seat throughout the crash sequence. During the rollover, the occupant was displaced alternately toward the roof, left, floor and right relative to the vehicle's orientation. She likely loaded the CRS harness straps and shell. At some point, the occupant's feet were possibly contacted by flying glass causing a minor laceration to the right foot and minor abrasion to the left foot.

When the vehicle came to rest, the occupant was leaning to the left in response to the final rest orientation of the Lexus. She was removed from the CRS by responders who arrived on-scene within 5 minutes following the crash. The police report indicated vomit was present around the occupant and CRS upon their arrival suggesting the child became sick at some time either just prior to, during, or following the crash. She was later transported by ambulance to a local hospital, where she was treated and released. Her GCS at the time of her examination was 15.

CRASH DIAGRAM



APPENDIX A:

2007 LEXUS GX470 EVENT DATA RECORDER REPORT[2]

Imaged by police and provided to SCI in PDF format

[2] The EDR report contained in this technical report was imaged using the current version of the Bosch CDR software at the time the police imaged the EDR.

BOSCH

CDR CRASH DATA RETRIEVAL

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	[redacted]
User	[redacted]
Case Number	[redacted]
EDR Data Imaging Date	[redacted]
Crash Date	[redacted]
Filename	[redacted]
Saved on	[redacted]
Imaged with CDR version	Crash Data Retrieval Tool 17.0
Imaged with Software Licensed to (Company Name)	[redacted]
Reported with CDR version	Crash Data Retrieval Tool 17.0
Reported with Software Licensed to (Company Name)	[redacted]
EDR Device Type	Airbag Control Module
Event(s) recovered	Rollover (1)

Comments

Direct-to-module connection in vehicle., cable 8617.

Manufacturer's "original tire size" - P265/65R17 front and rear, same as equipped on vehicle.

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 TechStream, 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 eight 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
- 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.
- The airbag ECU records post-crash data and may record pre-crash data in the event of a frontal/rear crash. In addition, it may record post-crash data in the event of a side crash or rollover.
- The airbag ECU has the following recording pages (memory maps) for each accident type to store event data: three pages for frontal or rear crash, one page for a side crash (if airbag ECU is applicable) , and one page for rollover events. (if airbag ECU is applicable)
- The data recorded by the airbag ECU in the event of a frontal/rear crash includes information that indicates the sequence and interval of each previously-occurring frontal/rear crash event.
  - Time from Previous TRG
  - TRG Count
- The point in time at which the recording trigger is established is regarded as time zero for the recorded data. For the time indicated in "Lateral Delta-V", "Roll Angle" or "Lateral Acceleration", the first sampling point after the recording trigger establishment is regarded as time zero. The time zero of the data and the recording trigger establishment do not always occur simultaneously.
- 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.
- The sampling interval of "Roll Angle" and "Lateral Acceleration" is 8 [ms] or 128 [ms]. A field indicating the sampling interval is not provided. The graph scaling can assist with determing the sample rate. The time zero is indicated by count (0).
- "Prior Event" is the event that occurred before the "1st Prior Event" that reached the greatest MAX Delta-V. Therefore, "Prior Event" is not always the prior event of "1st Prior Event".

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
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 6,000 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 126 km/h (78.3mph). 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
- The "Accelerator Rate" value is recorded as a voltage or level. In the case of voltage, the voltage increases as the driver depresses the accelerator. In case of the level, the following three levels are recorded.
  - FULL / MIDDLE / OFF
- "Accelerator Rate" may be recorded as "OFF" even if the accelerator pedal is depressed lightly. In addition, "FULL" may be recorded when the accelerator pedal is depressed strongly but not fully.
- The "Drive" setting for the "Shift Position" value indicates the shift position state is other than "R,"(Reverse), "N" (Neutral), or "P" (Park). It also includes communication disruption. Regardless of an actual shift position, "Drive" is always set for M/T vehicles because the shift position signal is not available.
- 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.
- "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.
- "TRG Count" indicates the number of frontal/rear recording triggers that have been established. The calculated value does not include the number of times side or rollover recording triggers have been established. The sequence in which each frontal/rear event occurred can be verified from the "TRG Count". The lesser the "TRG Count" value, the older the data. The upper limit for the recorded value is 255 times. When more than one event reaches the upper limit, the actual "TRG Count" may be greater than what is displayed for that event.
- Resolution of the "Time from Pre-Crash to TRG" is 100 [ms], and the value is rounded down and recorded.
- For "Time from Previous TRG", the recording trigger of side crash and rollover is not considered. The upper limit for the recorded value is 5000 [ms] or 5100 [ms] depending on the ECU part number. Resolution is 20 [ms] and the value is rounded down and recorded. When it's displayed as 5100ms, the actual "Time from Previous TRG" may be longer than what is displayed for that event.
- If 2 or more frontal/rear events occur successively within a period of 5000ms (or 5120ms for ECUs with 1.024 data sampling intervals), the actual sample time before the trigger is not displayed for subsequent events. The sample time before trigger will only be displayed for the first event of the successive events. For subsequent events (i.e second event or later events), the pre-crash "Time (sec)" data is replaced by integers -5 through -1 and the heading "Time (sec)" is replaced with "Sample Count". The time between "Sample Count" integers (-5 through -1) cannot be determined. The time between the last integer and TRG cannot be determined.
- "Pre-Crash Data Status" indicates data communication status of the vehicle. If communication disruption or other failure is occur, "Invalid" is set. Moreover, "Invalid" is set for some M/T vehicles because the shift position signal is not transmitted for them even if the other data is valid.

System Status at Time of Retrieval

ECU Part Number	89170-60241
ECU Generation	02EDR
Recording Status, All Pages	Complete
Diagnostic Trouble Codes Exist	No
Total Number of Front/Rear Crash Events	0
Freeze Signal	ON

Side/Rollover Event Record Summary at Retrieval

Events Recorded	Recording Status
Rollover	Not Supported

System Status at Front Airbag Deployment

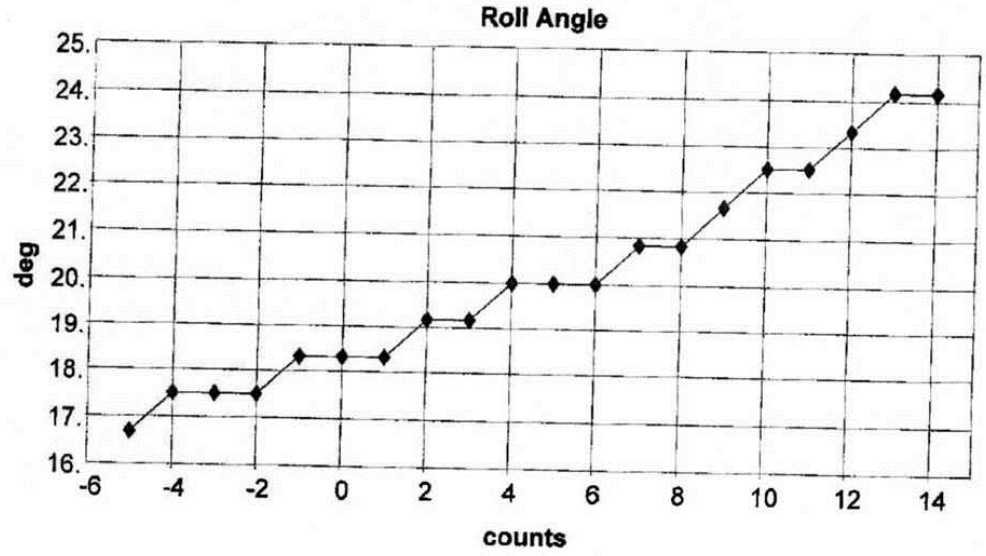
Time to Deployment Command, Front Airbag, Driver (msec)	0
Time to Deployment Command, Front Airbag, Passenger (msec)	0
Event Severity Status, Driver	N/A
Event Severity Status, Passenger	N/A

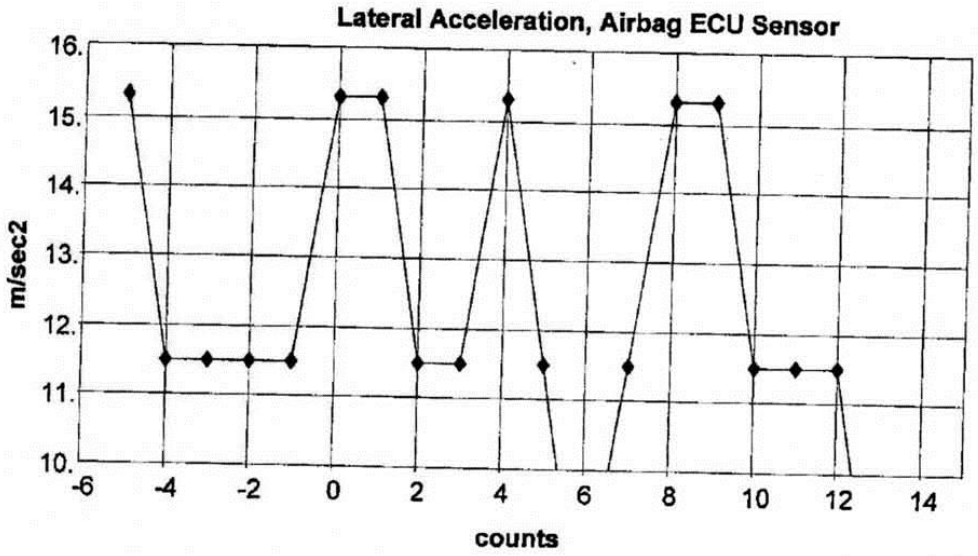
System Status at Rollover Event

RSCA Disable Switch	OFF
Time to Deployment Command, Rollover Airbag (msec)	89

Rollover Crash Pulse for Rollover Event (table 1 of 2)

Roll Angle Peak (degrees)	106





Rollover Crash Pulse for Rollover Event (table 2 of 2)

Counts	Roll Angle (degrees)	Lateral Acceleration, Airbag ECU Sensor (m/soc^2)
-5	16.7	15.3
-4	17.5	11.5
-3	17.5	11.5
-2	17.5	11.5
-1	18.3	11.5
0	18.3	15.3
1	18.3	15.3
2	19.2	11.5
3	19.2	11.5
4	20.0	15.3
5	20.0	11.5
6	20.0	7.7
7	20.8	11.5
8	20.8	15.3
9	21.7	15.3
10	22.5	11.5
11	22.5	11.5
12	23.3	11.5
13	24.2	7.7
14	24.2	7.7

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	B0 FE 00 00
	01	00 00 00 00
	02	(no response)
	03	04
	04	FF 02 FF 01
	09	30 30 30 30 30
	0A	30 30 30 30 30
	0B	30 30 30 30 30
	0C	30 30 30 30 30
	0D	36 30 32 34 31
	0E	30 30 30 30 30
	0F	30 30 30 30 30
	11	44 4E
	12	36 30 32 34 31
	13	01
	14	0E
	15	(no response)
	16	(no response)
	17	(no response)
	18	(no response)
	19	(no response)
	1A	(no response)
	1B	(no response)
	1C	(no response)
	1D	(no response)
	1E	(no response)
	1F	(no response)
	20	(no response)
	21	(no response)
	22	(no response)
	23	(no response)
	24	(no response)
	25	(no response)
	26	(no response)
	27	(no response)
	28	(no response)
	29	(no response)
	2A	(no response)
	2B	(no response)
	2C	(no response)
	31	(no response)
	32	(no response)
	33	(no response)
	34	(no response)
	35	(no response)
	36	(no response)
	37	(no response)
	38	(no response)
	39	(no response)
	3A	(no response)
	3B	(no response)
	3C	(no response)
	3D	(no response)
	3E	(no response)
	3F	(no response)
	40	30 30
	41	30 30 30 30 30
	42	00
	43	01
	44	(no response)
	45	30 30

```
46    30 30 30 30 30
47    00
48    01
49    ( no response )
4A    ( no response )
4B    ( no response )
51    ( no response )
52    ( no response )
53    ( no response )
54    ( no response )
55    ( no response )
56    ( no response )
57    ( no response )
58    ( no response )
59    ( no response )
5A    ( no response )
5B    ( no response )
5C    ( no response )
5D    ( no response )
5E    ( no response )
5F    ( no response )
60    ( no response )
61    14 15 15 15 16 16
62    16 17 17 18 18 18
63    19 19 1A 1B 1B 1C
64    1D 1D
65    14 15 15 15 16 16
66    16 17 17 18 18 18
67    19 19 1A 1B 1B 1C
68    1D 1D
69    04 03 03 03 03 04
6A    04 03 03 04 03 02
6B    03 04 04 03 03 03
6C    02 02
6F    00 59 7F FF 00
B0    00 00 00 00 00 00
B1    00 00 00 00 00 00
B2    00 00 00 00 FF 00
B3    FF FF FF FF FF FF
B4    FF FF FF FF FF FF
B5    FF FF FF FF FF FF
B6    00 00 00 00 00 00
B7    00 00 00 00 00 00
B8    00 00 00 00 00 00
B9    00 00 00 00 00 00
BA    00 00 00 00 00 00
BB    00 00 00 00 00 00
BC    00 00 00 00 FF 00
BD    FF FF FF FF FF FF
BE    FF FF FF FF FF FF
BF    FF FF FF FF FF FF
C0    00 00 00 00 00 00
C1    00 00 00 00 00 00
C2    00 00 00 00 00 00
C3    00 00 00 00 00 00
C4    00 00 00 00 00 00
C5    00 00 00 00 00 00
C6    00 00 00 00 FF 00
C7    FF FF FF FF FF FF
C8    FF FF FF FF FF FF
C9    FF FF FF FF FF FF
CA    00 00 00 00 00 00
CB    00 00 00 00 00 00
CC    00 00 00 00 00 00
CD    00 00 00 00 00 00
CE    00 00
CF    00 00 00
D0    ( no response )
D1    A5
D2    00 00 10
```

```
D3    ( no response )
E0    C0 10 00 00
E1    14 16
E2    16 18
EC    FF
```

Disclaimer of Liability

The users of the CDR product and reviewers of the CDR reports and exported data shall ensure that data and information supplied is applicable to the vehicle, vehicle's system(s) and the vehicle ECU. Robert Bosch LLC and all its directors, officers, employees and members shall not be liable for damages arising out of or related to incorrect, incomplete or misinterpreted software and/or data. Robert Bosch LLC expressly excludes all liability for incidental, consequential, special or punitive damages arising from or related to the CDR data, CDR software or use thereof.

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**National Highway
Traffic Safety
Administration**

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