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Special Crash Investigations: On-Site Air Bag Non-Deployment Crash Investigation; Vehicle: 2014 Audi Q5; Location: New York; Crash Date: April 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 multiple-event crash of a 2014 Audi Q5 and the non-deployment of its air bag systems. The Audi was involved in a back-plane impact by a 2006 Acura MDX, which initiated a loss of control that resulted in a left-side-leading, multiple quarter-turn rollover event for the Audi. The Audi was driven by a belted 67-year-old male with a belted 66-year-old female front-row right occupant at the time of the crash. Although the Audi was equipped with a certified advanced 208-compliant (CAC) frontal air bag system, front seat-mounted side impact air bags, and dual-sensing (side impact and rollover) inflatable curtain (IC) air bags, none deployed as a result of the crash. Both occupants of the Audi were transported by ambulances post-crash to a local hospital for evaluation and treatment of police-reported possible (C-level) injuries. As a result of this SCI investigation, it was determined that the lack of deployment of the Audi's supplemental inflatable restraint systems in relation to this crash was not an anomaly or a result of system malfunction. Rather, damage to the vehicle in relation to the initial rear impact event resulted in a loss of power in the vehicle's electrical systems that prevented ACM recognition of subsequent events and the ability to command deployment of inflatable supplemental restraint devices.

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Case Number: CR18015
Office of Defects Investigation
Vehicle: 2014 Audi Q5
Location: New York
Crash Date: April 2018

BACKGROUND

This report documents the on-site investigation of the multiple-event crash of a 2014 Audi Q5 (**Figure 1**) and the non-deployment of its air bag systems. The Audi was involved in a back-plane impact by a 2006 Acura MDX, which initiated a loss of control that resulted in a left-side-leading, multiple quarter-turn rollover event for the Audi. The Audi was driven by a belted 67-year-old male with a belted 66-year-old female front-row right occupant at the time of the crash. Although the Audi was equipped with a certified advanced 208-compliant (CAC) frontal air bag system, front-seat-mounted side impact air bags, and dual-sensing (side impact and rollover) inflatable curtain (IC) air bags, none deployed as a result of the crash. Both occupants of the Audi were transported by ambulances post-crash to a local hospital for evaluation and treatment of police-reported possible (C-level) injuries.

Figure 1. Left front oblique view of the 2014 Audi Q5 at the time of the SCI inspection.

Notification of the crash was received by the National Highway Traffic Safety Administration during May 2018. The notification was forwarded to the Special Crash Investigations (SCI) group and assigned to the team at Crash Research & Analysis for on-site investigation. The SCI team contacted the owner of the Audi and gathered information regarding the circumstances of the crash and then obtained a police crash report from the State's online records in May 2018. After achieving cooperation with the vehicles' insurers and coordinating with the Audi's manufacturer, the on-site investigation took place in June 2018. The on-site investigation included an inspection of the Audi conducted jointly with a representative from the Audi's manufacturer. The SCI investigator documented the Audi's exterior and interior damage, identified points of occupant contact, assessed the manual restraint systems, and inspected the supplemental restraint systems. Additional components of the on-site SCI investigation included an exterior inspection of the Acura, documentation of the crash site, and telephone interviews of the Audi's occupants.

Due to their dates of manufacture, neither the Audi nor the Acura was supported by the Bosch Crash Data Retrieval (CDR) tool/software. The SCI investigator was therefore unable to image any crash data from either vehicle during the inspection process. However, with permission from

the vehicle's insurer, the Audi's air bag control module (ACM) was removed from the vehicle and forwarded to the ACM's manufacturer for potential data retrieval and evaluation.

It should be noted that an SCI investigator typically uses a Nikon Nivo 5 +M Total Station Mapping System during documentation of an involved vehicle and crash site. However, at the time of this specific investigation, the SCI investigator's total station malfunctioned and was not operable. Applicable measurements, including crash scene physical environment dimensions and vehicle damage profiles, were obtained using traditional calibrated measuring devices.

As a result of this SCI investigation, it was determined that the lack of deployment of the Audi's supplemental inflatable restraint systems in relation to this crash was not an anomaly or a result of system malfunction. Rather, damage to the vehicle in relation to the initial rear impact event resulted in a loss of power in the vehicle's electrical systems that prevented ACM recognition of subsequent events and the ability to command deployment of inflatable supplemental restraint devices. A detailed discussion concerning the air bag non-deployment can be found later in this report. Although the manufacturer representative was unable to image any data from the vehicle during the inspection process, proprietary data retrieved from the Audi's ACM by its manufacturer supported the SCI investigator's findings.

SUMMARY

Crash Site

The crash occurred in the westbound lanes of a divided, limited-access roadway during daylight in April 2018. According to the National Weather Service, conditions in the locale at the time of the crash included mostly cloudy skies with a temperature of 10 °C (50 °F), a northwesterly breeze of 24 km/h (15 mph), and relative humidity of 46 percent.

The westbound portion of the roadway consisted of two travel lanes, which each measured 3.6 m (11.8 ft) in width. They were delineated by a single solid white right fog line, broken white center lane line, and single solid yellow median line. There were no shoulders; the outboard lane lines paralleled the road edges. The north roadside consisted of a level, grassy surface that contained a cable barrier system that paralleled the roadway an average distance of 3.6 m (11.8 ft) from the north roadway edge. The median varied in width and was populated by grass, shrubbery, and scattered trees. In the vicinity of the crash, the westbound portion was level and progressed along a slight right arching trajectory that had a radius of curvature of approximately 2900 m (9,514 ft).

Figure 2. North-facing view in the U-turn crossover, for the Audi's pre-crash travel trajectory.

In the vicinity of the crash, a U-shaped median crossover enabled eastbound traffic to reverse course and accelerate into the westbound lanes. The crossover itself measured 6.5 m (21.3 ft) wide at its apex, and transitioned into a 3.6 m

(11.8 ft) wide acceleration lane that progressed along the westbound lanes for approximately 100 m (328 ft). **Figure 2** shows the U-turn crossover, while **Figure 3** shows the merge lane and westbound travel lanes. Speed of traffic on the roadway was regulated by a posted limit of 56 km/h (35 mph). A crash diagram is included at the end of this technical report.

Pre-Crash

The Audi was driven by the belted 67-year-old male accompanied by a belted 66-year-old female front-row right occupant. They had just left a parking area west of the crash site, traveled east on the divided roadway, and merged left into the U-turn crossover. The driver told the SCI investigator during the interview that he looked east as he negotiated the left curve of the U-turn, and did not see any westbound traffic. He further stated he accelerated the Audi and began to merge right into the westbound travel lanes.

The Acura was traveling west in the right (outboard) travel lane of the multi-lane roadway. The belted 41-year-old male drove the Acura alone. According to law enforcement documentation of the crash, the Acura driver stated that as he approached the U-turn crossover, he looked down momentarily to adjust his radio. Law enforcement documentation of the crash determined that the Acura was traveling well in excess of the posted speed limit.

As the Audi accelerated, the driver merged from the acceleration lane into the left lane, then continued to merge to the right toward the right lane. The driver of the Acura looked up from adjusting his radio and observed the Audi encroaching into his lane from the left. The Acura driver braked and steered right, but was unable to avoid impact. There was no discernable physical evidence of either vehicle's pre-crash travel at the crash site during the SCI inspection.

Crash

The first crash event (Event 1) occurred as the front plane, left aspect of the Acura struck the back plane, right aspect of the Audi. Directions of

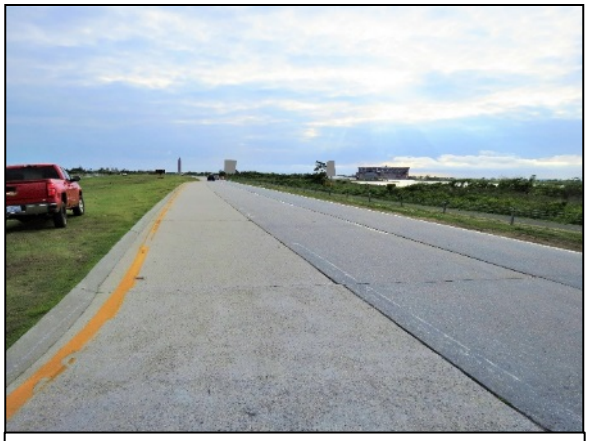


Figure 3. West-facing view of the merge lane and westbound travel lanes.

Figure 4. West-facing view of the area of impact in the left aspect of the right travel lane.

Figure 5. West-facing view of the Audi's tire marks, highlighted by red lines.

force were in the 12 o'clock sector for the Acura and the 6 o'clock sector for the Audi. Crash forces displaced the Audi forward and induced a counterclockwise rotation to the vehicle, redirecting it southwest. **Figure 4** shows the area of impact in the left aspect of the right travel lane, while **Figure 5** shows diverging tire marks from the Audi as it rotated counterclockwise away from the area of impact.

Lateral drag forces on the Audi's right side tires created an instability with respect to its center of mass, which tripped the Audi into a right-side-leading rollover when it achieved approximately 90 degrees of counterclockwise rotation. The vehicle rolled eight-quarter turns (two complete revolutions) over a distance of approximately 18 m (59.0 ft) from the roadway into the open grass median. According to law enforcement documentation, at final rest the Audi was centered approximately 7.6 m (25.0 ft) south of the road edge in the median.

The Acura was redirected toward the northwest by the crash forces and a right steering input by the driver. It departed the right roadway edge, and initiated a counterclockwise yaw as the driver counter-steered left in an attempt to maintain the roadway. The vehicle reentered the travel lanes, surpassed 180-degrees of total counterclockwise rotation and slid to final rest in the left westbound lane, facing northeast.

Post-Crash

Witnesses to the crash notified the local emergency response system, law enforcement, fire department, and emergency medical services personnel responded to the crash scene. All occupants of the Audi and Acura exited their vehicles under their own power. Ambulances transported all three to local hospitals for evaluation and treatment of possible (C-level) injuries. A local recovery service towed both vehicles from the crash site to a local yard. Each respective insurer subsequently deemed each vehicle a total loss, and each was transferred to the regional vehicle salvage facility, where they were located at the time of the SCI vehicle inspections.

2014 AUDI Q5

Description

The Audi (**Figure 6**) was manufactured in September 2013 and was identified by the VIN WA1LFAFP3EAxxxxxx. It was a 4-door sport utility vehicle (SUV) built on a 281 cm (110.6 in) wheelbase with a 2.0 liter, inline 4-cylinder gasoline engine. The Audi's electronic odometer reading at the time of the SCI inspection could not be determined due to electrical system inoperability. The Audi had a gross vehicle weight rating of 2,435 kg (5,368 lb). Front and rear axle ratings were 1,180 kg (2,601 lb) and 1,350 kg (2,976 lb), respectively. The curb weight was 1,850 kg (4,079 lb).

Figure 6. Right-plane view of the 2014 Audi Q5 at the time of the SCI vehicle inspection.

Placarding on the frame of the left front door indicated that the vehicle manufacturer's recommended tire size and cold tire pressure for all four axle positions was P235/60R18 at 220 kPa (32 PSI). At the time of the SCI inspection, the vehicle was equipped with Michelin Latitude

Tour HP tires of the recommended size at all four axle positions. All tires had ample tread. The left front, left rear, and right front tires remained inflated without damage or restriction. However, the right rear tire was deflated, had a cut in the sidewall from direct contact in the crash, and was restricted. The tires had matching tire identification numbers (TINs) of "61XF 007X 3013."

The interior of the Audi was configured for the seating of up to five occupants (2/3). The front row consisted of forward-facing bucket seats with adjustable head restraints. The front seats were capable of 25 cm (9.8 in) of seat track position adjustment. At the time of the SCI inspection, the driver's seat was adjusted 5 cm (2.0 in) forward of full-rear track position (rear-third) and the front right passenger's seat was adjusted 10 cm (4.0 in) forward of full-rear (middle third). Both front-row seat backs were slightly reclined. The driver's head restraint was positioned 8 cm (3.1 in) upward, while the front right passenger's head restraint was positioned 2 cm (0.8 in) upward. The Audi's second row consisted of a non-adjustable bench seat that had a capacity of three occupants. Manual safety features in the Audi included 3-point lap and shoulder seat belts for all five seat positions. The front seat belts were equipped with retractor pretensioners. Supplemental restraint systems in the Audi included the CAC frontal air bags, front seat-mounted side impact air bags, and dual-sensing IC air bags.

Figure 7. View of the Audi's Event 1 damage pattern from impact by the Acura.

Exterior Damage

Damage to the exterior of the Audi was located on the back and left planes, associative to the events of the crash. Back-plane damage was observed on the right aspect from the Event 1 impact by the Acura.

Figure 8. Back-plane view of the Audi's damage profile as documented during the SCI vehicle inspection.

Direct contact began 30 cm (11.8 in) right of center on the tailgate/hatch, and 41 cm (16.1 in) right of center on the bumper. There was a 12 cm (4.7 in) wide black transfer from tire contact by the Acura's left front tire on the right end of the Audi's back bumper. Direct contact width on the bumper beam measured only 15 cm (5.9 in) wide, centered 48 cm (18.9 in) right of center (Direct-D). A residual crush profile documented using a Field-L width across the entire 112 cm (44.1 in) back bumper beam of the Audi produced the following resultant measurements: C1 – C4 = 0 cm (0 in), C5 = 1 cm (0.4 in), and C6 = 2 cm (0.8 in). Maximum crush in the profile was observed to the right bumper corner. However, the greatest deformation was observed above the bumper beam to the right rear corner of the vehicle,

in the area of the right taillight (**Figure 7**). The right-rear quarter panel was deformed forward, exposing the rear aspect of the right-rear axle position. The right wheelbase was reduced by at least 3 cm (1.2 in). Based on the observed damage to the Audi, the Collision Deformation Classification (CDC) assigned for the Event 1 impact was 06BREE3. **Figure 8** shows the damage profile to the back of the Audi.

The damage algorithm of the WinSMASH model was used to calculate a vehicle velocity change (delta V) reconstruction of the crash. The calculated total delta V of the Audi for the Event 1 impact with the Acura was 12 km/h (7 mph). Longitudinal and lateral components of the calculated delta V were 12 km/h (7 mph) and 0 km/h (0 mph), respectively. These results were underestimated, due to the narrow overlap of the impact and minor bumper-level crush.

Rollover damage was visible to the right, top, and left planes of the Audi. On the right plane, a distinct pattern of vertically oriented abrasions were observed along the right front fender, right upper A-pillar, right roof side rail, and outermost protrusions of the right doors and right rear quarter panel. The abrasions continued from the right roof side rail and onto the top, with a slight directional shift toward the left rear. The roof was clean across the center aspect, and the roof rack bars were deformed inward with direct contact on both outer surfaces/edges.

A diagonal pattern of abrasions was observed to the left plane, with an orientation from front/top toward back/bottom. The pattern was most prevalent along the roof side rail at the upper A-pillar/windshield header junction, on the left front fender, and below the beltline on the left rear quarter panel. Combined, the abrasion patterns on the right, top, and left planes exhibited a

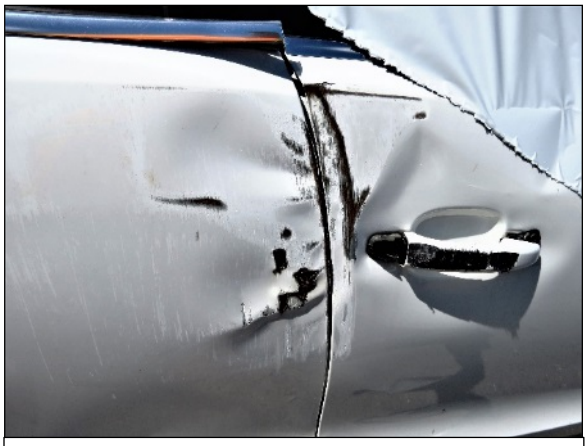


Figure 9. Close-up of the vertically oriented abrasions to the right doors of the Audi from the rollover.

Figure 10. Close-up view of the diagonally oriented abrasions to the rear left aspect of the Audi.

continuous rollover event that initiated right-side-leading and continued while the vehicle rotated counterclockwise. That is, the Audi completed eight total quarter-turns about its longitudinal axis while it maintained counterclockwise about its vertical axis and rotated an additional 90 degrees. In this manner, the Audi tripped right-side-leading while facing south, and came to final rest on its wheels facing east. **Figure 9** shows a close-up of the vertical abrasions on the right plane, while **Figure 10** shows a close-up of the diagonal abrasions on the left plane. The CDC assigned

to the Audi for the Event 2 rollover was 00TDDO1. No WinSMASH calculations could be computed because the event type was beyond the scope of the model's capabilities.

Event Data Recorder

The Audi was not equipped with an EDR supported by the Bosch CDR tool/software. Support of the Audi make/model vehicles began with the 2015 model year. Therefore, the SCI investigator could not image any data from the vehicle during the inspection process. However, with permission from the vehicle's insurer, the Audi's ACM was removed by the SCI investigator and forwarded to NHTSA for follow-up evaluation by the manufacturer.

The ACM's' manufacturer was successful in retrieving proprietary data from the module, conducted testing on the module to ensure operability, and provided results to NHTSA. These results were then shared with the SCI team. The manufacturer's report indicated that a rear crash event was detected, recorded, and stored by the ACM when the vehicle's odometer reading was 72,572 km (45,094 mi). At that time, the vehicle's lifetime operation timer was 1,645 hours, 4 minutes, and 59.1 seconds. The air bag warning lamp was "off."

Figure 11. Skin transfer from the driver's head on the left roof side rail and upper left B-pillar.

When the rear crash event was detected, both the driver and the front-row right seat belt buckle switch sensors were buckled. Their seat track position switch sensors indicated rear position adjustments. In response to the recognition of the rear crash event, the ACM commanded the actuation of the driver, front right passenger, second row left, and second row right pretensioners. In a timeframe from 90 to 99 milliseconds after the start of the rear algorithm, supply voltage was lost. No further data was recorded following the loss of electrical power. The ACM manufacturer conducted a visual inspection and performed an electrical function test, bench rollover test, and turntable rollover test of the module. The ACM passed all of these tests, and the manufacturer confirmed that the ACM was functional and had performed as designed.

Figure 12. Skin transfer from the front-row right occupant's head on the right roof side rail.

Interior Damage

The Audi's interior was inspected for crash-related damage, including intrusion and occupant contact. There was no occupant compartment intrusion to the first or second rows of the Audi's interior associated with the rear plane impact or rollover event. All four of the Audi's left and right doors remained closed during the crash and were operational post-crash. The backlight and

right front glazing both disintegrated from the associated impact forces, but there was no ejection of either occupant in the Audi.

Several areas of occupant contact were identified in the Audi that evidenced the kinematics of its occupants. There was skin transfer on the left roof side rail and left B-pillar from contact by the driver's head during the Event 2 rollover sequence. The driver's left knee contacted the left lower instrument during the rollover as well, producing a scuff to the polymer surface of the component. A skin transfer was also visible on the right roof side rail from contact by the front row right occupant's head during the rollover. Like the driver, an oily residue and possible scuff evidenced contact by her knee. **Figure 11** shows the driver contacts to the left roof side rail, while **Figure 12** shows the front-row right occupant's contact to the right roof side rail. There was no contact evidence associated with the occupants' initial kinematic response to the rear impact (Event 1) by the Acura.

Figure 13. Driver's latch plate in the Audi.

Manual Restraint Systems

The Audi was equipped with 3-point lap and shoulder seat belt systems for all five seating positions. The front seat belt systems used continuous loop webbing with sliding latch plates and adjustable D-rings. The driver's seat belt system retracted onto an emergency locking retractor (ELR), while the front right passenger's seat belt used an ELR/automatic locking retractor (ALR). Both front seat belt systems were equipped with retractor pretensioners.

At the time of the SCI inspection, the driver's D-ring was adjusted fully upward. Webbing was extended from the retractor, which was locked in position and did not retract the exposed webbing. The SCI investigator determined that the driver's pretensioner system was actuated. The webbing was observed to be gathered in the forward aspect of the latch plate, a result of occupant loading. The latch plate would not slide along the webbing, and was deformed by the gathered webbing (**Figure 13**). A polymer transfer extended toward the D-ring. The driver's latch plate was stuck in position 87 cm (34.3 in) above the lower anchor and 79 cm (31.1 in) below the D-ring. It was apparent that the driver was belted at the time of the crash.

Figure 14. Latch plate of the Audi's front-row right seat belt system, with webbing gathered in the belt path.

The front-row right occupant's D-ring was also adjusted fully upward at the time of the SCI inspection. The overall condition of the front right seat belt system was very similar to the driver's with webbing gathered in the belt path of the latch plate (**Figure 14**). Webbing was

extended from the retractor, which was locked in position and did not retract the exposed webbing. The front right seat belt system's retractor pretensioner was also actuated. The latch plate would not slide along the webbing, and was deformed by the gathered webbing. A polymer transfer extended toward the D-ring. The front-row right occupant's latch plate was stuck in position 70 cm (27.6 in) above the lower anchor and 73 cm (28.7 in) below the D-ring. It was apparent that the front-row right occupant was belted at the time of the crash.

Supplemental Restraint Systems

The Audi was equipped with front seat belt retractor pretensioners and multiple inflatable supplemental restraints. These included a CAC frontal air bag system that consisted of frontal air bags for the driver and front right passenger positions, with seat belt buckle switch sensors, seat track position sensors, and a front right occupant presence (weight) sensor. The Audi was further equipped with front seat-mounted side impact and dual-sensing (side impact and rollover) IC air bags mounted in the roof side rails.

According to the Audi's driver, the vehicle had not been involved in any prior crashes where supplemental devices (pretensioners or air bags) were actuated or deployed. The supplemental restraint systems were original equipment, and had not required or received any specific service or maintenance. The pretensioners in the Audi actuated as a result of the crash. However, none of the vehicle's inflatable air bags deployed. Proprietary data imaged from the ACM by its manufacturer confirmed that the air bag warning lamp was "off" at the time of the crash.

NHTSA Recalls and Investigations

A query of the Audi's VIN on www.safercar.gov identified two open recalls and no investigations concerning this specific 2014 Audi Q5 vehicle as of the date of this report. The first recall was identified by the NHTSA Recall Number 17V622 and was issued on October 5, 2017. This recall concerned the wiring of the auxiliary heater, which could become corroded and melt, posing a risk of potential fire. There was no record of the Audi receiving service for this recall. The second recall was identified by the NHTSA Recall Number 18V229 and was issued on May 16, 2018, after the date of the crash under investigation. This recall concerned the electric pump of the coolant system, which could potentially overheat and result in a fire.

Air Bag Non-Deployment Discussion

None of the Audi's available inflatable supplement air bags deployed in the incident crash. However, both front seat belt retractor pretensioners had actuated. Due to the make and model of the Audi, it was not supported by the Bosch CDR software/tool, and the SCI investigator had no means by which to obtain any data from the vehicle's ACM.

The SCI inspection of the Audi was attended by a representative from the vehicle's manufacturer. This representative attempted to interrogate the vehicle's systems and retrieve data from the vehicle pertaining to the crash events under investigation. The representative connected a proprietary tool to the vehicle's diagnostic link connector, which communicated with a proprietary software program on a laptop computer. External power was supplied to the vehicle's low-voltage electrical system via direct connection of an external power pack to the terminals of the Audi's battery. After the representative was unsuccessful in getting the proprietary system to communicate with the vehicle due to electrical power issues, a second power supply was connected to the Audi's front jumper terminals.

Despite application of multiple power sources to the vehicle at the same time, the manufacturer representative and SCI investigator were unable to energize the instrument cluster, engine, or ignition circuits of the Audi. The only electrical components of the Audi they were able to successfully energize were the low-voltage vanity and interior lights, the radio system, and the center instrument panel controls (climate control system, etc.). As a result of the electrical power issues, the manufacturer representative's proprietary tool and software were unable to communicate with the vehicle, and no data could be retrieved. **Figure 15** shows the proprietary software screen, indicating that the tool was connected to the vehicle, but could not communicate with the ignition system or retrieve its status.

Figure 15. Laptop screen view of the manufacturer's software indicating that the system did not recognize ignition status; therefore, the air bags did not deploy.

Figure 16. Crushed electronic module located in the right rear quarter panel area of the Audi and directly involved in the Event 1 impact deformation.

During the process of diagnosing the electrical power issues, the manufacturer representative and SCI investigator identified an electronic control module adjacent to the battery system in the rear of the vehicle that had become involved in the immediate damage pattern associated with the rear impact (Event 1). This module, which may have been related to the trailer hitch wiring, was entirely crushed (**Figure 16**).

As a result of the SCI inspection, the following conclusions regarding the Audi and the non-deployment of its inflatable supplemental restraint systems were determined:

1. Due to its age, the Audi was not supported by a commercially available crash data retrieval tool/software. A manufacturer representative participated in the SCI inspection and attempted to image data, but was unable to energize the necessary vehicle systems in order to do so.
2. Electrical power issues during the vehicle inspection process prevented illumination of the Audi's instrument cluster, thus preventing identification of any illuminated warning lamps. However, the driver reported during the interview that none of the warning lamps was illuminated prior to the crash.
3. Proprietary data retrieved from the ACM by its manufacturer confirmed that the air bag warning lamp was "off" prior to the crash.

4. The initial rear impact event of the crash sequence (Event 1) involved damage and deformation to the right rear corner area of the Audi. This destroyed an electronic control module and compromised the integrity of the vehicle's low-voltage electrical systems.
5. Damage to the aforementioned electronic circuits resulted in electrical power issues to the vehicle following initial impact, and prior to the initiation of the secondary event (Event 2 rollover). This was confirmed by the propriety data retrieved from the ACM by its manufacturer, which indicated a loss of electrical power to the ACM that occurred 90 to 99 milliseconds after recognition of the rear crash event.
6. The Audi's seat belt pretensioner systems actuated during the crash sequence, as observed/documented during the SCI inspection and confirmed by the data imaged from the Audi's ACM. The pretensioner actuation was associated with the recognition of the rear crash event (Event 1).
7. Due to the damage sustained in relation to the rear impact, the corresponding compromise of the vehicle's low-voltage electrical systems, and the resulting loss of power to the ACM, the Audi's ACM was unable to recognize the rollover (Event 2). Because there was no power to the ACM and it could not recognize the occurrence of the rollover event, it was also unable to command deployment of any of the Audi's inflatable supplemental restraint systems.

Based on the aforementioned circumstances, the lack of deployment of the Audi's supplemental inflatable restraint systems in relation to this crash was determined not to be an anomaly or result of system malfunction. Rather, damage to the vehicle in relation to the initial rear impact event resulted in a loss of power in the vehicle that prevented ACM recognition of subsequent events and the ability to command inflatable supplemental restraint deployment.

2014 AUDI Q5 OCCUPANT DATA

Driver Demographics

Age/sex:	67 years/male
Height:	188 cm (74 in)
Weight:	109 kg (240 lb)
Eyewear:	None
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Seat between middle and rearmost track position
Manual restraint usage:	3-point lap and shoulder seat belt
Usage source:	Vehicle inspection
Air bags:	Frontal, seat-mounted, and IC air bags available; none deployed
Alcohol/drug data:	None
Egress from vehicle:	Exited under own power
Transport from scene:	Ambulance to local hospital
Type of medical treatment:	Treated and released

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Concussion without loss of consciousness	161001.2	Left roof side rail, left B-pillar junction	Certain

Source: emergency room records.

Driver Kinematics

The 67-year-old male driver was positioned in the Audi's driver seat, with the seat back slightly reclined and the track in a rearward position that was 5 cm (2.0 in) forward of full-rear. He used the available 3-point lap and shoulder seat belt system, evidenced by the post-crash condition of the system as observed by the SCI investigator during inspection.

He drove the Audi eastbound, merged into the U-turn crossover, and negotiated the sharp left curvature of the crossover. He then accelerated the vehicle westbound as the Audi entered the westbound merge lane and steered the vehicle to the right, across the left westbound lane and into the right westbound lane. At impact by the Acura, the Audi's seat belt pretensioner systems actuated. The driver initiated a rearward trajectory, and his posterior loaded the seat back. Crash forces were distributed across the entire surface area of the driver's posterior, providing him with a ride-down of the impact.

As the Audi rotated counterclockwise and tripped into the right-side-leading rollover sequence, the driver was redirected toward his left by the centrifugal forces of the rollover. His head contacted the area of the junction of the left roof side rail and left B-pillar, evidenced by the skin transfer observed during the SCI inspection. This contact and loading resulted in the concussion. The driver's left knee contacted and scuffed the left lower instrument panel, but no medically documented injuries resulted from this contact. Due to his belted status and the actuation of the seat belt pretensioners that had removed slack from the webbing, the driver was prevented from being displaced about the Audi's interior during the crash sequence.

The driver remained in the driver's seat position as the vehicle came to final rest. He unbuckled the seat belt system and exited the vehicle under his own power. Following the arrival of emergency response personnel, he was transported by ambulance to a local hospital for the evaluation of C-level injuries. The driver was treated and released on the same day as the crash.

Front-Row Right Occupant Demographics

Age/sex:	66 years/female
Height:	173 cm (68 in)
Weight:	68 kg (150 lb)
Eyewear:	None
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Seat between middle and rearmost track position
Manual restraint usage:	3-point lap and shoulder seat belt
Usage source:	Vehicle inspection
Air bags:	Frontal, seat-mounted, and IC air bags available; none deployed
Alcohol/drug data:	None

Egress from vehicle: Exited under own power
Transport from scene: Ambulance to local hospital
Type of medical treatment: Admitted for one day

Front-Row Right Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Concussion without loss of consciousness	161001.2	Right roof side rail	Certain
2	Contusion of pancreas	542810.2	Seat belt webbing	Possible
3	Superficial abrasion to right elbow	710202.1	Right door panel, rear upper quadrant	Certain
4	Superficial abrasion to right posterior forearm	710202.1	Right door panel, rear upper quadrant	Certain

Source: emergency room records.

Front-Row Right Occupant Kinematics

The 66-year-old female occupied the front-row right position of the Audi. She had adjusted the seat back slightly reclined and the track to a rearward position that was 10 cm (3.9 in) forward of full-rear. She used the available 3-point lap and shoulder seat belt system, evidenced by the post-crash condition of the system as observed by the SCI investigator during inspection.

At impact by the Acura, the Audi's seat belt pretensioner systems actuated. The front-row right occupant initiated a rearward trajectory, and her posterior loaded the seat back. Crash forces were distributed across the entire surface area of her posterior, providing her with a ride-down of the impact.

As the Audi rotated counterclockwise and tripped into the right-side-leading rollover sequence, the front-row right occupant was redirected toward her right by the centrifugal forces of the rollover. Her head contacted the right roof side rail, evidenced by the skin transfer observed during the SCI inspection. This contact and loading resulted in the concussion. Her right knee contacted the right lower instrument panel, but no medically documented injuries resulted from this contact.

Due to her belted status and the actuation of the seat belt pretensioners that had removed slack from the webbing, the front-row right occupant was prevented from being displaced about the Audi's interior during the crash sequence. She remained belted and in the vehicle as it came to final rest. The front-row right occupant unbuckled the seat belt system and exited the vehicle under her own power. She was transported by ambulance by emergency response personnel to a local hospital for the evaluation of C-level injuries. The front-row right occupant was hospitalized overnight and released one day after the crash.

2006 ACURA MDX

Figure 17. Left front oblique view of the 2006 Acura MDX at the time of the SCI vehicle inspection.

Description

The Acura (**Figure 17**) was manufactured in April 2006 and was identified by the VIN 2HNYD18256Hxxxxxx. It was a 4-door SUV built on a 270 cm (106.3 in) wheelbase with a 3.5-liter, V-6 gasoline engine. The Acura's electronic odometer reading at the time of the SCI inspection could not be determined due to electrical system inoperability. The vehicle had a gross vehicle weight rating of 2,600 kg (5,730 lb). Front and rear axle ratings were 1,310 kg (2,890 lb) and 1,335 kg (2,945 lb), respectively. The curb weight was 1,992 kg (4,392 lb). Placarding on the frame of the left front door declared that the vehicle manufacturer's recommended tire size and cold tire pressure for all four axle positions was P235/65R17 at 220 kPa (32 PSI). At the time of the SCI inspection, the vehicle was equipped with Sumitomo Touring LSH tires of the recommended size at all four axle positions. All tires had ample tread and remained inflated without damage or restriction. The front tires had matching TINs of "R8L8 3DJR 4216," while the rear tires had matching TINs of "R8L8 3MJR 1614."

The Acura was configured for the seating of up to seven occupants (2/3/2). Manual safety features included 3-point lap and shoulder seat belts for all seat positions. Supplemental restraint systems in the Acura included frontal and IC air bags.

Exterior Damage

Damage to the exterior of the Acura was located on the front and left planes, associative to the frontal impact event with the back plane of the Audi. Direct contact began 41 cm (16.1 in) left of center on the front bumper beam and extended 23 cm (9.1 in) to the left front bumper corner. In the damage profile was minor crush to and rotation of the front bumper beam, with crush and deformation to the hood and left front fender. The left headlight assembly was disintegrated, the front bumper fascia and grille were separated, and underhood components were displaced.

A residual crush profile documented using a Field-L width across the entire 128 cm (50.4 in) front bumper beam of the Acura produced the following resultant measurements: C1 = 8 cm (3.1 in), C2 = 9 cm (3.5 in), C3 = 6 cm (2.4 in), C4 = 6 cm (2.4 in), C5 = 5 cm (2.0 in), and C6 = 4 cm (1.6 in). Maximum crush in the profile was observed to the left front bumper corner. However, the greatest deformation was observed above the bumper beam to the left front fender area, above the left headlight assembly (**Figure 18**). The left wheelbase was shortened by at least 9 cm (3.5 in). The CDC assigned for the Event 1 impact to the Acura was 12FLEE4. **Figure 19** shows the damage profile to the front of the Acura.

The damage algorithm of the WinSMASH model was used to calculate a vehicle velocity change (delta V) reconstruction of the crash. The calculated total delta V of the Acura for the Event 1 impact with the Audi was 13 km/h (8 mph). Longitudinal and lateral components of the

calculated delta V were -13 km/h (-8 mph) and 0 km/h (0 mph), respectively. These results were underestimated, due to the narrow overlap and minor bumper-level crush to the Audi.

Figure 18. View of the Acura's front plane Event 1 damage pattern.

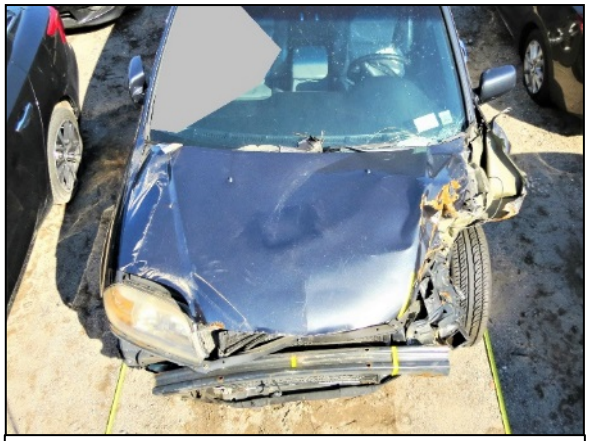
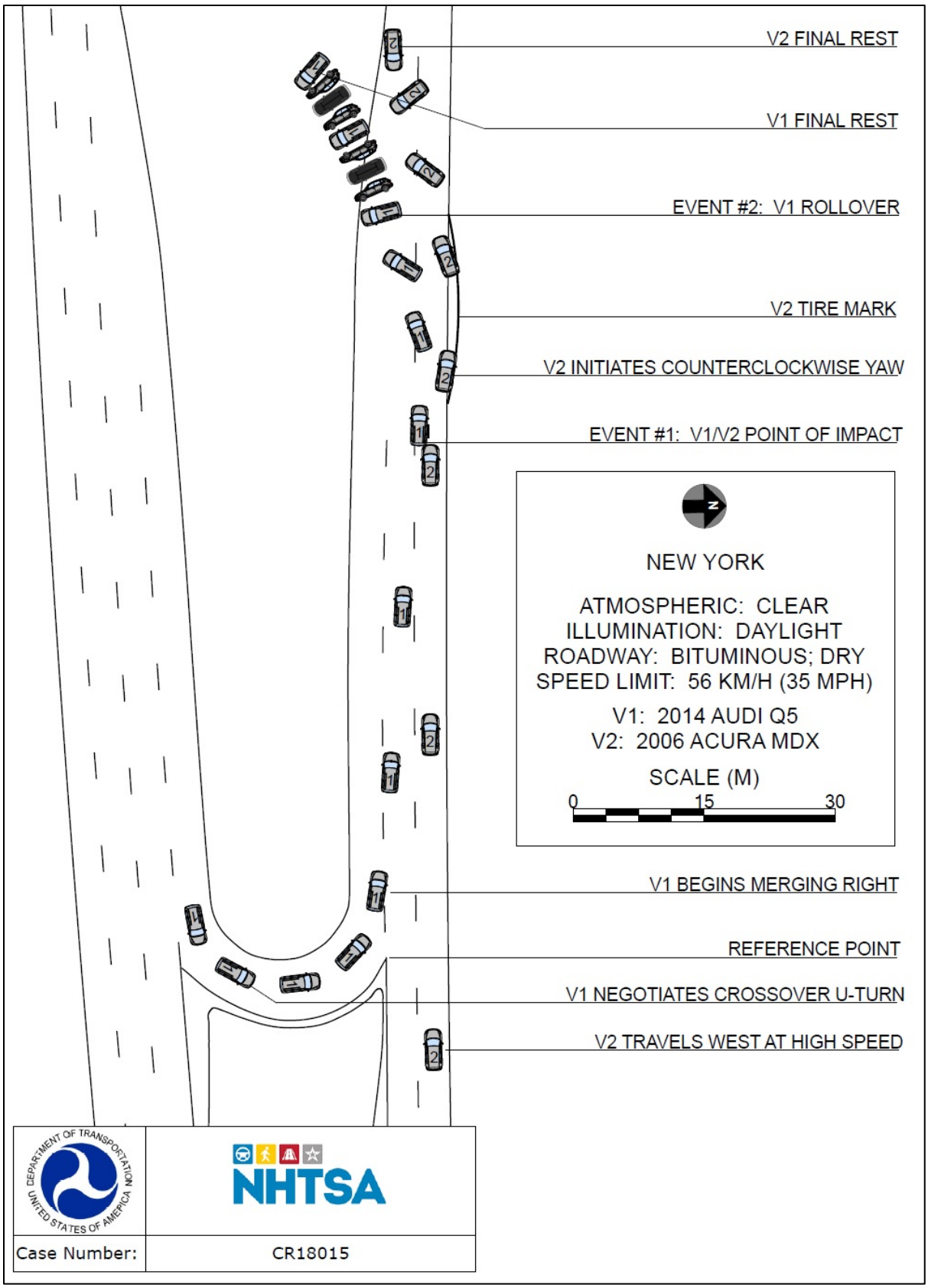


Figure 19. Overhead perspective view of the damage pattern to the Acura's front plane.

Occupant Data

According to the police crash report, the Acura was driven by a belted 41-year-old male at the time of the crash. Following the crash, he complained of left elbow/arm pain and was transported by ambulance to a local hospital for reported C-level injuries. His diagnosis and treatment course remains unknown.

CRASH DIAGRAM



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