U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

NHTSA

DOT HS 813 064

January 2021

Special Crash Investigations: On-Site Alleged Air Bag Inflator Rupture Crash Investigation; Vehicle: 2009 Kia Spectra; Location: Kansas; Crash Date: March 2018

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Crash Research & Analysis, Inc. (2021, January). *Special Crash Investigations: On-Site Alleged Air Bag Inflator Rupture Crash Investigation; Vehicle: 2009 Kia Spectra; Location: Kansas; Crash Date: March 2018* (Report No. DOT HS 813 064). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 813 064		

4. Title and Subtitle	5. Report Date
Special Crash Investigations: On-Site Alleged Air Bag Inflator Rupture Crash Investigation; Vehicle: 2009 Kia Spectra; Location: Kansas; Crash Date: March 2018	January 2021 6. Performing Organization Code
7. Author Crash Research & Analysis, Inc.	**8. Performing Organization Report No.** CR18018
9. Performing Organization Name and Address Crash Research & Analysis, Inc. P.O. Box 302 Elma, NY 14059	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTNH22-12-C-00269
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	**13. Type of Report and Period Covered** Technical Report **14. Sponsoring Agency Code**

15. Supplementary Notes

Each crash represents a unique sequence of events, and 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.

16. Abstract

This report documents the on-site investigation of a crash involving a 2009 Kia Spectra and the alleged rupture of the driver's air bag inflator. The Kia struck the back plane of a 2006 Ford Escape that was stopped in traffic on a multi-lane roadway at a controlled intersection. Safety systems in the Kia included 3-point manual lap and shoulder seat belts with front retractor pretensioners, Certified Advanced 208-Compliant frontal air bags, front seat-mounted side impact air bags, and side impact inflatable curtain (IC) air bags. The driver's seat belt retractor pretensioner actuated, and the driver's frontal air bag deployed as a result of the crash. As a result of the crash, the Kia's driver frontal air bag deployed. The Kia's belted 86-year-old female driver sustained police-reported injuries in the crash and was transported by ambulance to a local hospital, where it was determined that she had suffered a traumatic brain injury. The driver died seven days later. The SCI investigation determined that all components of the driver's frontal air bag were original manufacturer equipment and that there was no evidence of inflator rupture or air bag malfunction. The driver's frontal air bag inflator was intact and undamaged, and the driver's frontal air bag had deployed as designed. These findings were verified and corroborated by the Kia manufacturer's representative. The deployment of the driver's frontal air bag did not play a role in the driver's injuries. The driver's fatal injuries were attributed to her head/face contact with the steering wheel rim.

17. Key Words	18. Distribution Statement
alleged inflator rupture, underride, subdural hematoma	The document is available to the public from the National Technical Information Service, www.ntis.gov.

19 Security Classif. (of this report)	20. Security Classif. (of this page)	21 No. of Pages	22. Price
Unclassified	Unclassified	17	

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On-Site Alleged Air Bag Inflator Rupture Crash Investigation
Office of Defects Investigation
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Vehicle: 2009 Kia Spectra
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BACKGROUND

This report documents the on-site investigation of a crash involving a 2009 Kia Spectra (**Figure 1**) and the alleged rupture of the driver's air bag inflator. The Kia struck the back plane of a 2006 Ford Escape that was stopped in traffic on a multilane roadway at a controlled intersection. Safety systems in the Kia included 3-point manual lap and shoulder seat belts with front retractor pretensioners, Certified Advanced 208-Compliant (CAC) frontal air bags, front-seat-mounted side impact air bags, and side impact inflatable curtain (IC) air bags. The driver's seat belt retractor pretensioner actuated and the driver's frontal air bag deployed as a result of the crash. The Kia's belted 86-year-old female driver sustained police-reported injuries in the crash and was transported by ambulance to a local hospital, where it was determined that she had suffered a traumatic brain injury. The driver died seven days later.

Figure 1. Left front oblique view of the Kia at the time of the SCI vehicle inspection.

Notification of the crash was provided by family of the Kia's driver to the National Highway Traffic Safety Administration in July 2018. The notification was forwarded to the Special Crash Investigations (SCI) group and assigned for on-site investigation. The on-site investigation took place in August 2018 and involved a detailed inspection of the Kia vehicle and crash site. A technical representative from the Kia vehicle's manufacturer participated in the inspection. The Kia was not equipped with an air bag control module (ACM) supported by the Bosch Crash Data Retrieval (CDR) tool; therefore, the SCI investigator was unable to image any Event Data Recorder (EDR) information from the vehicle. The manufacturer representative used a proprietary tool/software to connect to the vehicle's systems. Due to the period of the vehicle's manufacture, there was no recorded pre-crash or deployment timing data. The available data imaged by the proprietary tool only related to current and historical diagnostic trouble codes (DTCs), which indicated that the driver's pretensioner and driver's air bag circuits were open (i.e., deployed/actuated). The Ford was not available for SCI inspection.

The SCI investigation determined that all components of the driver's frontal air bag were original manufacturer components, and there was no evidence of inflator rupture or air bag malfunction. The driver's frontal air bag inflator was intact and undamaged, and the driver's frontal air bag had deployed as designed. These findings were verified and corroborated by the Kia

manufacturer's representative. Evidence documented during the vehicle inspection indicated that the driver was belted, most likely with the shoulder portion of the webbing under her arm at the time of the crash. Through her kinematic response, she loaded the seat belt system with her abdomen/torso and loaded through the deployed frontal air bag, contacting the steering wheel rim with her head/face. Her head/face contact to the steering wheel rim resulted in a subdural hematoma and facial fractures, which, in conjunction with her age and associated comorbidities, were contributory to her death.

SUMMARY

Crash Site

The crash occurred in the eastbound portion of a multi-lane roadway, immediately west of an intersection, in the morning hours of March 2018. According to the National Weather Service, conditions in the locale at the time of the crash included cloudy skies and windy conditions, with a temperature of 9 °C (49 °F), a west-northwest wind of 61 km/h (38 mph), and a relative humidity of 22 percent. The physical environment of the roadway and intersection was documented during the SCI crash site inspection using photographs and a Nikon Nivo 5.M+ total station mapping system.

Figure 2. East-facing view of the roadway in the vicinity of the crash site.

The roadway was level in the area of the crash. The eastbound portion of the roadway consisted of three travel lanes, delineated by single white lane lines. The left lane measured 3.6 m (11.8 ft) wide, the center lane was 3.3 m (10.8 ft) wide, and the right lane was 3.5 m (11.5 ft) wide. On approach to the intersection, the right lane transitioned into a right turn only lane. The left and center lanes continued eastbound beyond the intersection. Traffic for all travel directions was controlled at the intersection by overhead electronic signals. On approach to the intersection from a distance from the west, the roadway was not physically divided. However, an elevated grass median strip populated sporadically with trees that measured 6.6 m (21.7 ft) wide at its maximum divided the roadway beginning 67 m (220 ft) west of the intersection. Road edges were bordered by raised concrete curbs. **Figure 2** depicts the roadway and intersection on approach from the west. Speed of traffic was regulated by a posted limit of 64 km/h (40 mph). A crash diagram is included at the end of this technical report.

Pre-Crash

The Kia was occupied by the belted 86-year-old female driver. She operated the vehicle in an easterly direction in the left lane of the multilane roadway. In front of the Kia, the Ford also traveled east in the left lane of the roadway. The Ford approached the intersection and came to a controlled stop in response to the red light. The driver of the Kia did not initially recognize the stopped Ford, and the Kia maintained speed along its eastbound travel.

Late in the pre-crash sequence, however, the driver of the Kia applied the brakes and steered to the right in an attempt to avoid the crash. The front of the vehicle pitched down. Although there

was no physical evidence documented on the roadway by law enforcement or electronic data recorded in the vehicle to support these conclusions, the underride characteristics of the Kia's frontal damage profile could not have occurred without such an avoidance attempt by the Kia's driver. SCI inspection of the vehicle determined there was no direct contact damage to the front bumper of the Kia.

Crash

The crash occurred as the front plane of the Kia underrode and struck the rear plane of the stopped Ford in the left lane of the multilane roadway. Directions of force were in the 12 o'clock sector for the Kia and the 6 o'clock sector for the Ford. Associated crash forces resulted in the actuation of the Kia driver's seat belt retractor pretensioner and the deployment of the Kia driver's frontal air bag system. The impact displaced the Ford eastward, in alignment with the Kia's trajectory, and both vehicles came to final rest facing east in the left lane of the roadway. Despite the forward displacement of the Ford from the impact, it was not of sufficient distance to involve any of the other vehicles stopped in traffic.

Post-Crash

Witnesses contacted the local emergency response system to report the crash. Law enforcement, fire department, and emergency medical services personnel responded to the crash scene. The driver of the Kia was transported by ambulance to a local hospital for evaluation and treatment of her injuries. She was subsequently hospitalized for a subdural hematoma and multiple facial fractures and expired seven days after the crash. The Ford's driver was not injured.

A local towing service removed the Kia from the crash site and transferred it to a local yard. The Kia's insurer subsequently deemed it a total loss, and it was transferred to the regional vehicle salvage facility, where it was located at the time of the SCI vehicle inspection. The Ford was driven from the crash scene; it could not be located for SCI inspection.

2009 KIA SPECTRA

Description

The Kia (**Figure 3**), identified by the Vehicle Identification Number KNAFE221795xxxxxx, was manufactured in February 2009. It was a 4-door sedan built on a 259 cm (102.0 in) wheelbase with a 2.0 liter, inline, 4-cylinder gasoline engine. The Kia's electronic odometer reading was 146,473 km (91,014 mi) at the time of the SCI inspection. The Kia had a gross vehicle weight rating of 1,780 kg (3,924 lb). Front and rear axle ratings were 980 kg (2,161 lb) and 960 kg (2,116 lb), respectively. The curb weight was 1,225 kg (2,701 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 were P195/60R15 at 210 kPa (30 PSI). Specific tire data at the time of the SCI inspection were as follows on the next page:

Figure 3. Right plane view of the 2009 Kia Spectra at the time of the SCI vehicle inspection.

Position	Make/Model	TIN	Tread Depth	Restriction	Damage
LF	Mastercraft MC-440	RMRB FW9 1016	6 mm (8/32 in)	Yes	Tire flat, de-beaded
LR	Mastercraft MC-440	RMRB FW9 4516	7 mm (9/32 in)	No	No
RR	Mastercraft MC-440	RMRB FW9 1415	6 mm (7/32 in)	No	No
RF	Zouglas	MDRB MFIR 3013	4 mm (5/32 in)	No	No

The interior of the Kia 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, while the second row consisted of a non-adjustable bench seat that had a capacity of three occupants. Manual safety features in the Kia included 3-point lap and shoulder seat belts for all five seat positions. Supplemental restraint systems included the front seat belt retractor pretensioners, CAC frontal air bags, front-seat-mounted side impact air bags, and side impact IC air bags.

Exterior Damage

Damage to the exterior of the Kia was located on the front plane, associative to the frontal crash event with the back plane of the Ford. There was no direct contact damage or deformation from the impact with the Ford discernable at the bumper level; all the direct contact damage was located above the bumper beam. This included three distinct areas of direct contact: (1) immediately left of center on the Kia's hood; (2) the right front headlight assembly (disintegrated); and (3) the left front headlight, left front fender, and left front tire/wheel. **Figures 4** and **5** depict the front plane and left front corner of the Kia with the direct contact damage from the underride impact with the Ford. Note that the area of rust-colored scuffs on the bumper fascia between the license plate contour and the right front bumper corner are from post-crash forklift movement of the Kia by the salvage facility.

Figure 4. View of the Kia's front plane damage as documented during the SCI inspection.

Figure 5. Left view of the Kia and the area of damage to the left front fender from the Ford's left rear wheel.

It was apparent to the SCI investigator that the three areas of damage were related to contact with the Ford's trailer hitch (damage to Kia's hood left of center), right rear axle position (Kia's right front headlight), and left rear axle position (Kia's left front headlight, fender, and left front

tire/wheel). The damage pattern indicated that the Kia's driver had initiated a sudden braking and right steering maneuver prior to impact, which caused the front of the Kia to pitch downward and offset the Kia to the right. The braking maneuver allowed the Kia's front plane to underride the Ford's rear plane. The resulting damage pattern to the Kia was consistent only with a crash avoidance sequence as described.

Residual crush profiles were documented at the bumper beam level and upper radiator support level. The Field-L width spanned 130 cm (51.2 in) across the end width of the Kia. The averaged profile resultant measurements included C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 1 cm (0.4 in), C5 = 0 cm, and C6 = 9 cm (3.5 in). Maximum crush in the profile was observed to the right corner of the upper radiator support. The left wheelbase was reduced 14 cm (5.5 in). Based on the observed damage to the Kia, the Collision Deformation Classification (CDC) assigned for the front plane underride impact with the Ford's back plane was 12FDEW1.

The "missing 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 Kia for the Event 1 impact was 14 km/h (8 mph). Longitudinal and lateral components of the calculated delta V were -14 km/h (-8 mph) and 0 km/h (0 mph), respectively. These borderline results were considered low, in part due to the above bumper damage and the averaging technique of the crush profile measurements relative to the stiffness coefficients used by the WinSMASH program. Additionally, a significant portion of the deformation energy was absorbed through the vehicle's suspension and frame during the left wheelbase reduction, which was not accounted in the calculation. The barrier equivalent severity of the crash was an estimated 24 to 32 km/h (15 to 20 mph) based on SCI experience.

Event Data Recorder

The Kia was not equipped with an EDR supported by the Bosch CDR tool/software. Therefore, the SCI investigator could not image any data from the vehicle during the inspection process.

The representative of the Kia's manufacturer used a proprietary tool/software to interrogate the vehicle's systems during the vehicle inspection process. Due to the period of the vehicle's manufacture, there was no recorded pre-crash or deployment timing data. The only available data related to current and historical diagnostic trouble codes (DTCs), which indicated that the driver's pretensioner and driver's air bag circuits were open. This related to the actuation of the driver's pretensioner and the deployment of the driver's frontal air bag in the crash.

Interior Damage

The interior of the Kia was inspected for crash-related damage, including intrusion and occupant contact. At the time of the SCI vehicle inspection, the driver's seat was adjusted to its middle track position, with the seat back slightly reclined. It was not damaged, and retained its pre-crash positioning. There was no occupant compartment intrusion to the first or second rows of the vehicle's interior associated with the crash. All four of the Kia's left and right doors remained closed during the crash and were operational post-crash. The Kia's glazing all remained intact and undamaged, and none was contacted by the occupant.

An inspection of the Kia's interior for occupant contact revealed three distinct and identifiable areas of damage from occupant contact. This included two separate scuffs to the left lower instrument panel from the driver's left and right knees, as well as blood and make-up transfer on the face of the deployed driver's air bag. The left knee contact was located immediately left of the contour for the steering column, while the right knee contact was located beneath the steering column. The make-up transfer was centered on the bottom left of the circular center stitch pattern, while the blood transfer was located on the lower left quadrant of the air bag's face. **Figure 6** depicts the driver's knee contacts, while **Figure 7** depicts the driver air bag contacts.

Figure 6. Driver knee contacts to the Kia's left lower instrument panel.

Figure 7. Driver contact evidence on the face of the Kia's deployed driver air bag.

Manual Restraint Systems

The Kia 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). All three second row systems were equipped with ELR/ALR retractors. The front row seat belt systems were equipped with retractor pretensioners.

Figure 8. Webbing of the driver seat belt system in the Kia with polymer transfer from the latch plate.

The driver's retractor pretensioner was actuated, and the webbing was locked in an extended position. The D-ring was adjusted to a three-quarter upward height position at the time of the SCI inspection, and there was 175 cm (68.9 in) of exposed webbing. In a normal stowed position, the total possible length of exposed webbing would have been 82 cm (32.3 in). There was a 4

cm (1.6 in) polymer transfer on the webbing (**Figure 8**) from latch plate loading, located 89-93 cm (35.0-36.6 in) above the lower anchor.

Loading evidence was also visible in the belt path of the latch plate (**Figure 9**). It was apparent to the SCI investigator that the driver's seat belt system was in use at the time of the crash. However, based on the combination of the exposed webbing's length in conjunction with the driver's demographics and the track position of the driver's seat, it is possible that driver had the shoulder portion of the webbing routed beneath her left arm.

Figure 9. Loading on the Kia driver's latch plate.

Supplemental Restraint Systems

The Kia was equipped with front seat belt 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 Kia was further equipped with front seat-mounted air bags and roof side rail-mounted IC air bags that were designed for deployment in side-impact crashes.

According to a commercially available vehicle history report, the Kia had not been involved in any prior crashes. The supplemental restraint systems were original equipment and had not required or received any specific service or maintenance.

As a result of the crash under investigation, the driver's retractor pretensioner actuated, and the driver's frontal air bag deployed. The deflated driver's air bag measured 68 cm (26.8 in) in overall diameter, with a 14 cm (5.5 in) diameter circular center stitch pattern. A pair of 4 cm (1.6 in) diameter vent ports were located on the back of the air bag at the 10 and 2 o'clock positions. Two distinct areas of occupant contact were discernable on the face of the deployed driver's air bag, including an area of drops of blood on the lower left quadrant and an area of make-up transfer on the lower aspect of the center stitch pattern. The location of these contacts on the air bag (**Figure 10**) supported the SCI investigator's reconstruction of the crash (driver right steering maneuver corresponding to clockwise steering wheel rotation) and the hypothesis that the shoulder portion of the driver's seat belt might have been routed beneath the driver's left arm.

Figure 10. View of the Kia's deployed driver air bag at the time of the SCI vehicle inspection.

NHTSA Recalls and Investigations

At the time of this report, a query of the NHTSA website, using the 2009 Kia Spectra's VIN, identified that there were no open recalls or investigations concerning this specific vehicle.

Air Bag Inflator Rupture Allegation Discussion

The individual who reported the crash to NHTSA alleged that the air bag inflator potentially had ruptured during deployment and that the driver had sustained fatal injuries during the deployment of the driver's frontal air bag.

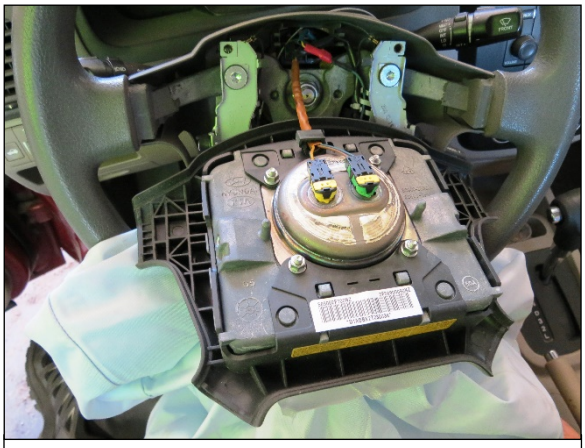


Figure 11. Driver's frontal air bag module during removal from the Kia's steering wheel hub.

During the vehicle inspection process, the driver's frontal air bag/module was removed from its steering wheel hub-mounted location and disassembled for inspection. Several Torx fasteners were unscrewed from the steering wheel hub to facilitate removal of the module. The SCI investigator observed that the cover flap and module appeared to be the manufacturer's genuine original equipment. Proper manufacturer markings and serialization codes were observed on the module and inflator components (**Figure 11**).

There was no damage or abnormal wear, with no evidence to suggest that the module would not/did not operate as designed. Polymer connectors and wiring in the vehicle were intact, with no evidence of tampering or modification.

Figure 12. View of the Kia driver's frontal air bag inflator at the time of the SCI vehicle inspection.

Four nuts were unfastened, and the inflator was removed from the driver's frontal air bag module. Examination of the inflator revealed that the electrical connections were in pristine condition, with no evidence of corrosion or degradation. The inflator was intact, and there was no evidence of abnormal condition or damage. The ventilation holes were all open from the deployment (**Figure 12**).

As a result of this SCI investigation, it was determined that all components of the driver's frontal air bag were OEM and that there was no evidence of inflator rupture or air bag malfunction. These findings were verified and corroborated by the Kia manufacturer's representative during the joint vehicle inspection.

2009 KIA SPECTRA OCCUPANT DATA

Driver Demographics

Age/sex:	86 years/female
Height:	157 cm (62 in)
Weight:	64 kg (140 lb)
Eyewear:	None
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Seat at middle 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; frontal deployed
Alcohol/drug data:	None
Egress from vehicle:	Assisted through the left front door
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Hospitalized, died seven days after the crash

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Cerebrum hematoma (hemorrhage) subdural, No Further Specificity	140650.3	Tandem IPC Left Air Bag - Steering wheel hub Steering wheel rim	Possible Probable
2	Mandible fracture, Right No Further Specificity	250600.1	Isolated Front - Steering wheel rim	Probable
3	Facial bone(s) fracture, No Further Specificity	250400.1	Isolated Front - Steering wheel rim	Probable
4	Skin/subcutaneous/ muscle laceration-> minor; superficial, No Further Specificity	210602.1	Isolated Left Air Bag - Steering wheel hub	Certain
5	Skin/subcutaneous/ muscle abrasion, No Further Specificity	210202.1	Isolated Left Air Bag - Steering wheel hub	Certain

Source: coroner's report, surrogate interview.

Driver Kinematics

The 86-year-old female driver was positioned in the Kia's driver seat, with the seat back slightly reclined and the track adjusted to a middle position. She was belted with the shoulder portion of the webbing that was most likely positioned under her left arm as evidenced by the post-crash condition of the seat belt system, which was observed by the SCI investigator during inspection. The driver operated the Kia eastbound on the multilane roadway. She approached the Ford, but she did not immediately recognize that it was stopped in traffic at the intersection.

Immediately prior to impact, the driver provided a braking and right steering maneuver. The front plane of the Kia underrode and struck the rear plane of the Ford. The driver initiated a forward trajectory in response to the 12 o'clock direction of force. This was accompanied by her loading the seat belt system, evidenced by the abrasions on the latch plate and transfer on the webbing as documented during the SCI vehicle inspection. The driver translated forward, and her knees contacted the left lower instrument panel, evidenced by the pair of scuff marks observed by the SCI investigator during the vehicle inspection.

The driver's head flexed forward, and her face contacted and loaded through the deployed driver's frontal air bag to the steering wheel rim. Contact to the air bag was evidenced by blood and make-up transfer on the air bag's fabric. Contact/interaction with the steering wheel rim was evidenced by the fracture of the mandible and unspecified facial bones and the subdural hematoma. The driver's contact and engagement with the deployed driver's air bag and steering wheel rim might have been exacerbated by the probable routing of the shoulder portion of the seat belt system beneath her left arm, which would have exposed her to increased forward flexion of her upper body.

The driver rebounded into the driver's seat as the Kia came to final rest with its front plane engaged and under-ridden beneath the Ford's back plane. Emergency personnel evaluated the driver at the crash site and transported her by ambulance to a local hospital. She was admitted for treatment, fell into a coma, and underwent surgery in relation to her multiple head/face and brain injuries. The driver did not recover from her injuries, was transferred into end of life care, and died seven days after the crash.

2006 FORD ESCAPE

Description

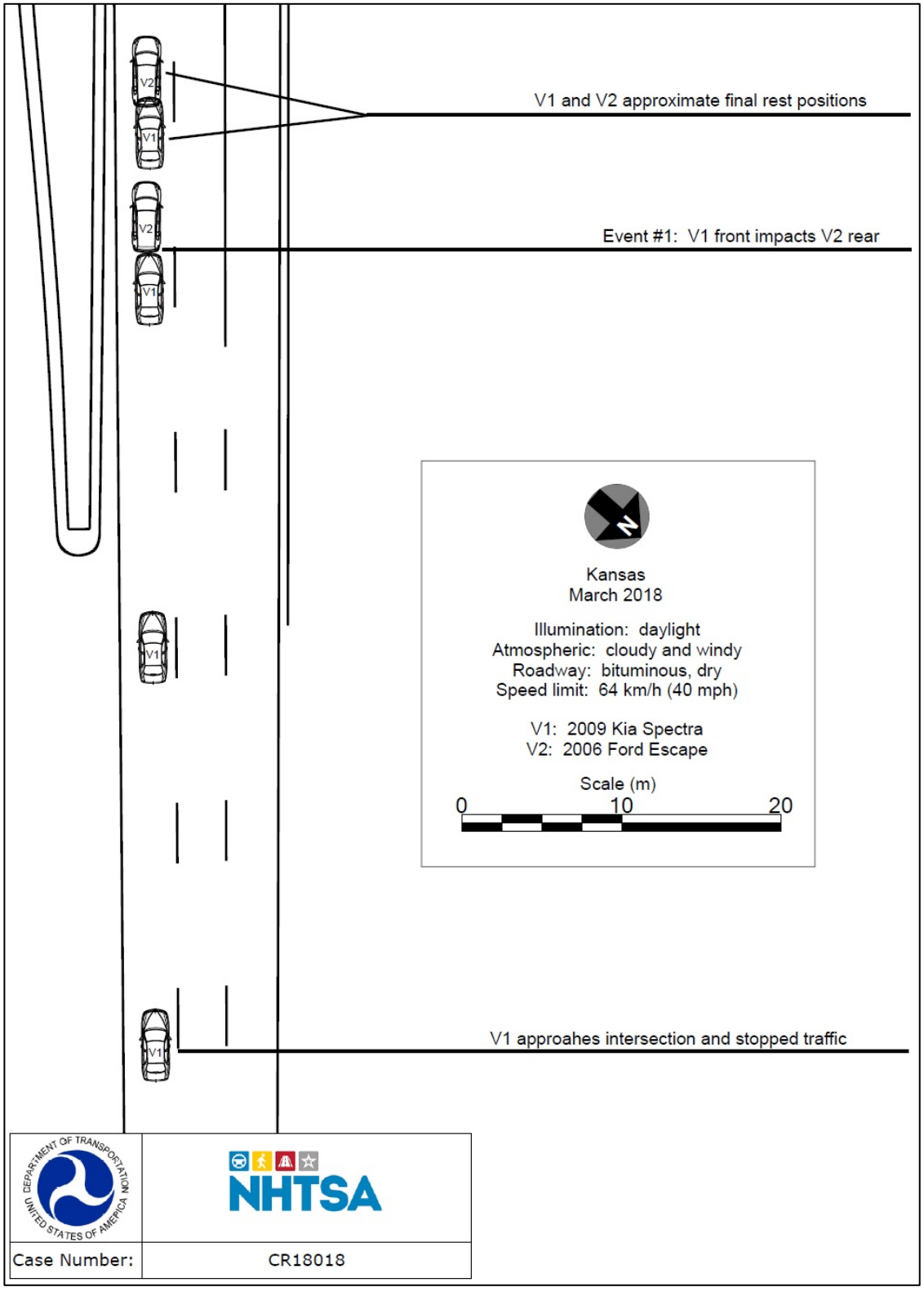
The 2006 Ford Escape was an SUV identified by the Vehicle Identification Number 1FMYU93106Kxxxxxx and equipped with the XLT trim package. The all-wheel drive platform was configured on a 262 cm (103.1 in) wheelbase and was powered by a 3.0 liter, V6 gasoline engine that was linked to a 6-speed automatic transmission. Service brakes were a power-assisted front/rear disc system with ABS. The Ford's curb weight was 1,571 kg (3,463 lb). The interior of the vehicle was configured with two rows for the seating of up to five occupants (2/3) with a rear cargo area. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seat positions. Both front seat belts were equipped with buckle pretensioners. Supplemental restraint systems consisted of the driver and passenger frontal air bags.

The Ford, which did not sustain disabling damage during the crash, was driven away from the crash site. It was not inspected during this SCI investigation.

Occupant Data

The Ford was driven by a belted 21-year-old female. This driver complained of tenderness/ soreness to her back but refused medical attention or transport from the scene. She drove the Ford away from the crash site at the conclusion of the law enforcement investigation.

CRASH DIAGRAM



DOT HS 813 064
January 2021

U.S. Department
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**National Highway
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15076-012121-v2