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Special Crash Investigations: On-Site Air Bag Inflator Rupture Investigation; Vehicle: 2004 BMW 325i; Location: Arizona; Crash Date: September 2020

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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 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 the inflator rupture of the driver's frontal air bag in a 2004 BMW 235i involved in a crash with another vehicle. The unbelted 16-year-old male BMW driver was struck by one or more metal fragments from the inflator and sustained fatal injuries. Takata Corporation representatives who reviewed police photographs of inflator fragments recovered after the crash suggested that it was likely a PSDI-4 Takata inflator produced in April 2004. The Special Crash Investigations team inspected the air bag inflator, and the manufacturer's labeling on the component indicated that it was manufactured by Takata in 2004. The crash occurred during the afternoon hours in September 2020 in Arizona. The other vehicle, a 2018 Toyota Corolla, was driven by a belted 26-year-old male. The BMW was traveling southbound, and the Toyota was eastbound preparing to turn left from a shopping center driveway. The Toyota driver accelerated entering the southbound lanes and was struck by the front plane of the BMW. The BMW driver's frontal air bag deployed, the inflator ruptured, and a metal fragment penetrated the driver's abdomen, causing serious and moderate-severity injuries. He was transported by ambulance to a local hospital, where he was pronounced deceased one hour after the crash. The medical examiner later recovered the inflator fragment from the driver's body. Police photographs revealed that the air bag sustained tears in the fabric and that additional inflator fragments were present in the air bag. The Toyota driver was not injured or transported.

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Special Crash Investigations
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Office of Defects Investigation
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Location: Arizona
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Background

This report documents the on-site investigation of the inflator rupture of the driver's frontal air bag in a 2004 BMW 235i (Figure 1) involved in a crash with another vehicle. The unbelted 16-year-old male BMW driver was struck by at least one metal fragment from the ruptured inflator and sustained fatal injuries.

Figure 1. The 2004 BMW 325i

Takata Corporation representatives reviewed police photographs of inflator fragments recovered after the crash and suggested that it was likely a PSDI-4 Takata inflator produced in April 2004. The Special Crash Investigations (SCI) team inspected the air bag inflator, and the labeling on the component indicated that it was manufactured by Takata in 2004. The driver's frontal air bag was subject to a manufacturer safety recall issued in May 2015, which declared: "during air bag deployment in an accident, the driver's front air bag module may produce excessive internal pressure that could cause the inflator to rupture." The passenger's frontal air bag was subject to a similar recall in July 2014. The passenger's frontal air bag did not deploy in the crash. It is unknown if a remedy was sought by the current or previous vehicle owner concerning the recalls.

The National Highway Traffic Safety Administration's Office of Defects Investigation initiated the investigation in response to a notification from an attorney to an SCI investigator in September 2020. The SCI group assigned the case to the SCI team in October 2020. The BMW was being held at a private storage facility by an attorney representing the owner. The SCI team contacted the attorney, who scheduled the vehicle inspection to include SCI, the OEM, the investigating police detective, parties associated with the attorney, and a representative of the other driver's employer. The inspection was completed in November 2020. The BMW's air bag

control module (ACM) was not supported by the Bosch Crash Data Retrieval (CDR) system. The OEM technician present at the vehicle inspection did not attempt to obtain EDR or other electronic data from the BMW. The SCI team did not have permission to remove the ACM or any component other than the driver's frontal air bag.

The other vehicle involved in the crash was a 2018 Toyota Corolla. The attorney who coordinated the BMW inspection also coordinated an inspection of the Toyota at a separate site that included all parties present at the BMW inspection. The Toyota was supported by the Bosch CDR system, but according to the attorney, the insurance company would not grant permission for any parties to image the EDR, so SCI did not obtain crash data from the Toyota.

The crash occurred during the afternoon hours in September 2020 in Arizona. The crash site was a two-way, north/south roadway with a continuous left turn lane located in an urban area. The BMW was being driven southbound at an unknown speed by the unbelted 16-year-old male. The Toyota was being driven by a belted 26-year-old male who was stopped and facing east in preparation to depart a shopping center parking lot. The Toyota driver accelerated from a stop, entered the southbound lanes, intending to turn left, and the front plane of the BMW struck the left plane of the Toyota. The BMW driver's frontal air bag deployed, and the driver sustained a laceration to his abdomen. Both vehicles came to rest on the roadway. The BMW driver was transported by ambulance to a local hospital, where he was pronounced deceased one hour after the crash. The BMW was held in evidence by the police, and the Toyota was towed due to disabling damage. The Toyota driver was not injured. The SCI team obtained the police report and on-scene photographs. Police photographs revealed that the air bag was torn and that fragments of the ruptured inflator were present in the air bag. The medical examiner later recovered a metal fragment of the air bag inflator from the driver's body.

Summary

Crash Site

The crash site was a two-way roadway with a continuous left turn lane located in an urban area of Arizona (Figure 2). The roadway was oriented north and south. It was paved with asphalt and was straight and level. The posted speed limit was 72 km/h (45 mph), and conditions at the time of the crash were daylight, clear, and dry. The roadway had two through lanes for each direction separated by a center, two-way, left turn lane, and included bike lanes along the east and west curbs. The travel lanes measured 3.3 m (10.8 ft) in width, and the bike lanes including gutters measured 1.7 m (5.6 ft) in width. The through lanes were separated by dashed white painted stripes and were bordered on the right by white painted fog lines. The center, two-way, left turn lane was bordered by solid and dashed yellow painted stripes.

Figure 2. The 2004 BMW 235i driver's perspective in approach to crash site looking south

A shopping center parking lot was located on the west side of the roadway. A driveway, oriented east and west and measuring 7.7 m (25.3 ft) in width, intersected the southbound lanes near the area of impact. A crash diagram is included at the end of this report.

Pre-Crash

The BMW was being driven southbound in the second lane from the right by the unbelted 16-year-old male. The driver later stated to emergency responders that he was traveling 72 to 80 km/h (45 to 50 mph). He also stated that he was unbelted. The Toyota was being driven eastbound at an unknown speed as it exited the parking lot and entered the roadway. The BMW remained in its original lane, and it was not known if the driver attempted any evasive maneuvers. The Toyota crossed over the bike lane and first southbound lane before entering the second southbound lane, crossing over the path of the BMW. Crush damage patterns documented on the two vehicles suggest that the Toyota driver likely steered right in an evasive maneuver prior to impact. The estimated heading angles were 180 degrees for the BMW and 100 degrees for the Toyota.

Crash

The front plane of the BMW struck the left plane of the Toyota in an angled configuration. The observed principal directions of force were 20 degrees for the BMW and 280 degrees for the

Toyota. The area of impact was in the second southbound lane from the right. Following the impact, the BMW rotated slightly counterclockwise, traveled roughly 6 m (20 ft) in a southbound trajectory, and came to rest facing south in the second southbound lane from the right. The Toyota initiated a post-impact counterclockwise rotation and traveled roughly 10 m (33 ft) in a southeast trajectory before coming to rest facing northeast in the second northbound lane from the right. The Toyota driver then accelerated from a stop and drove the vehicle roughly 12 m (39 ft) in a northbound trajectory, bringing the vehicle to a controlled stop near the east curb (Figure 3). At impact with the Toyota, the BMW driver's frontal air bag deployed. Details of the air bag are discussed in later sections of this report.

For the BMW, the WinSMASH program using the standard calculation type with damage analysis calculated at total delta V of 14 km/h (9 mph), a longitudinal delta V of -14 km/h (-8 mph), a lateral delta V of -5 km/h (-3 mph), and a barrier equivalent speed (BES) of 21 km/h (13 mph). For the Toyota, the WinSMASH calculated a total delta V of 18 km/h (11 mph), a longitudinal delta V of -3 km/h (-2 mph), a lateral delta V of 17 km/h (11 mph), and a BES of 11 km/h (7 mph). The WinSMASH results fit the model and were considered reasonable.

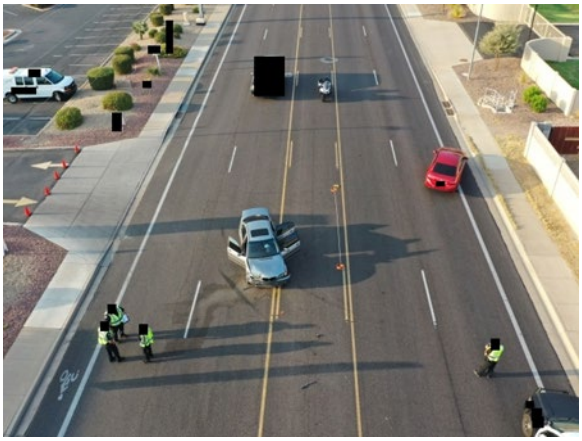


Figure 3. Area of impact (Event 1) looking north; the BMW on left, the Toyota on right (police photo)

Post-Crash

The BMW driver exited the vehicle under his own power and without assistance. According to a witness, soon after exiting the vehicle the driver collapsed to the ground. EMS arrived on-scene and made contact with the driver within five minutes after being dispatched. They departed the scene 19 minutes after dispatch, transporting the driver by ambulance to a local hospital, where they arrived 30 minutes after dispatch. During the transport, the driver had a Glasgow Coma Score (GCS) of 15, he was alert and talking, and his condition was described as unchanged. However, his EMS report noted that his verbal responses were inappropriate and that while restrained on the patient cot, he was flailing his arms about and not following simple commands. Following his arrival at the hospital and his transfer to a hospital bed, the driver became unresponsive, his breathing stopped, and he was in a state of cardiac arrest. When the hospital trauma team arrived at the bedside, the driver's GCS was 3, and he did not have a pulse. Resuscitative efforts by the trauma team were unsuccessful. The driver sustained abdominal

injuries ranging in severity from minor to serious and was declared deceased in the hospital emergency department one hour after the crash. The Toyota driver was not injured or transported. Both vehicles were towed due to damage.

2004 BMW 325i

Description

The 2004 BMW 325i was identified by the Vehicle Identification Number (VIN) WBAEV334X4Kxxxxxx. The vehicle was manufactured in June 2004, and the mileage was unknown due to the absence of power to the electronic odometer. The last known odometer reading reported in July 2018 in a vehicle history report was 223,678 km (138,987 mi). The BMW had a 2.5-liter, 6-cylinder gasoline engine; a rear-wheel drive; an automatic transmission; power steering and brakes; antilock brakes; a tilt and telescoping steering functionality; power windows; and a power moon roof. The vehicle manufacturer recommended size P205/55R16 tires for the front and rear. It had a Kumho Solus TA31 tire manufactured in an unknown year on the left front, a Westlake Radial RP18 tire manufactured in an unknown year on the left rear, a Definity HP100 tire manufactured in 09/2017 on the right rear, and a Sentury Touring tire manufactured in 01/2018 on the right front. All the tires were of the recommended size.

The front row was configured for seating two occupants with forward-facing bucket seats and adjustable head restraints. The driver's seat track was set between the middle and full-rearward settings, with the outside track overlap measuring 13 cm (5.1 cm). The seat back was in a slightly reclined position. The vehicle had an adjustable tilt and telescoping steering column set to the full-up and full-forward position. The steering wheel rim was outfitted with a padded faux leather Custom Accessories aftermarket steering wheel cover manufactured in 2013.

Exterior Damage

The BMW struck the Toyota in a front plane to left plane configuration (Figure 4). Direct damage to the front plane measured at bumper level began 30 cm (11.8 in) right of the front left bumper corner and extended 124 cm (48.8 in) to the right ending at the front right bumper corner. The field L was distributed from bumper corner to bumper corner and measured 154 cm (60.6 in). Eighteen measurements were taken at bumper level using the Nikon total station, and the Faro Blitz tool calculated six crush measurements as follows: C_1=0 cm, C_2=0 cm, C_3=3 cm (1.2 in), C_4=9 cm (3.5 in), C_5=17 cm (6.7 in), and C_6=15 cm (5.9 in). Maximum crush was located 50 cm (19.7 in) left of the front right bumper corner, and the Collision Deformation Classification (CDC) for the BMW in Event 1 was 01FDEW1.

Figure 4. Front plane damage, the 2004 BMW 325i

The left front tire was flat and de-beaded. The right front tire was restricted, the sidewall was cut, the rim was bent, and the wheel was displaced rearward 5 cm (2.0 in), reducing the wheelbase by the same length. The rear tires and wheels were unremarkable.

Interior Damage

The BMW interior sustained damage caused by the driver's frontal air bag deployment. The vehicle sustained no glazing damage, integrity loss, or intrusion. The driver was unbelted and contacted the deployed air bag and the ruptured inflator fragment.

Manual Restraint Systems

The BMW had manual, three-point, continuous loop seat belts for the front row seats. The belts had retractor and buckle pretensioners. Based on the evidence obtained during the inspection, the driver's medical records, and the driver's statement, the BMW driver appeared to be unbelted. The driver's belt and buckle revealed evidence of historical usage but not of occupant loading. During the inspection, the belt unspooled from the retractor as intended, and when inserted, the latch plate was held in the buckle as intended. The buckle and stalk measured 23 cm (9.1 in) in length and was undamaged. None of the front seat belt pretensioners appeared to have actuated during the crash.

Supplemental Restraints Systems

The BMW had a supplemental restraint system that included driver and passenger frontal air bags, driver and passenger door-mounted side impact air bags, and front row retractor and buckle seat belt pretensioners. The driver's frontal air bag was determined to be original equipment. It is unknown if the other non-deployed air bags were original equipment. A vehicle history report indicated that the vehicle had four previous owners and that no service or repair was reported from July 2018 to September 2020. A crash of unknown severity involving another vehicle was reported in October 2010 during the vehicle's second ownership. Recalls for the passenger and driver frontal air bags were initiated in 2014 and 2015 during the vehicle's third ownership. The vehicle history report did not include service records relating to either recall.

The driver's frontal air bag deployed at impact with the Toyota (Figure 5). The air bag had one vent port at the upper aspect of the back panel and did not have tethers. It was circular in shape and measured 50 cm (19.7 in) from seam to seam. At least one known metal fragment displaced from the ruptured inflator penetrated the air bag, causing a tear in the fabric. Other tears and holes suggested that more than one fragment may have exited the air bag. One tear located on the lower right quadrant of the front panel measured 9 cm (3.5 in); two small holes measuring 1 cm (0.4 in) in diameter were located in this area. Two tears located in the lower left and right aspects of the back panel measured 4 cm (1.6 in) and 3 cm (1.2 in), respectively. Additionally, the front panel was torn vertically from the top seam to the bottom seam (Figure 6). Given the driver's unbelted status and the probable movement at impact relative to the direction of force, the driver likely loaded the air bag with his chest and abdomen. Slight blood deposits were present on the lower aspect of the front panel. The upper and lower cover flaps appeared to have opened normally and were unremarkable. The vehicle's other air bags did not deploy, and none of the seat belt pretensioners actuated.

Figure 5. Deployed driver's frontal air bag, the 2004 BMW 325i

Figure 6. Deployed driver's frontal air bag, the 2004 BMW 325i

Ruptured Air Bag Inflator Discussion

The air bag inflator ruptured during deployment. At least three metal fragments displaced from the area of the metal inflator cap of the inflator were recovered following the crash. Police responding on-scene found two fragments measuring 5 x 3 cm (2.0 x 1.2 in) located inside the deployed air bag. The third fragment identified by Takata as a booster tube and measuring 4 x 3 cm (1.6 x 1.2 in) in size passed through the air bag fabric. It penetrated and entered the driver's abdomen, causing lacerations to the stomach, small bowel, liver, right kidney, inferior vena cava, and right psoas muscle, with associated extensive intra-abdominal hemorrhage. The fragment was recovered by the medical examiner from the soft tissue of the driver's back during the autopsy.

The Takata inflator had two booster tubes. The second appeared to be undamaged and remained in place on the inflator. The advanced air bag had two stages of deployment, and according to the OEM technician who attended the inspection, the post-deployment state of the inflator indicated that it deployed the first stage only.

During the vehicle inspection, the OEM technician removed the BMW's deployed driver's frontal air bag module from the steering wheel hub by removing two T30 torx screws and two wiring harnesses. During the removal, the technician noted that the screws were tight and that the harnesses were undamaged. The labeling on the air bag module confirmed that it was manufactured by Takata Corporation. Following its removal from the steering wheel, the technician removed the ruptured air bag inflator from the air bag by removing four 8 mm (0.3 in) hex nuts and two wiring harnesses. The technician noted that the hex nuts were tight and that the harnesses were undamaged. The labeling on the inflator indicated that it was manufactured in 2004. Examination of the inflator revealed rupture type damage and missing components from the area of the metal cap (Figure 7). It was suggested by the OEM that, based on its labeling and overall appearance, the air bag was likely original to the vehicle. During their review of the police photos, Takata engineers recognized physical characteristics of a fragment they determined to be a component belonging to a Takata programmable smokeless driver inflator

(PSDI)-4 manufactured in its La Grange, Georgia, facility in 2004. They did so by identifying a circular feature on the back side of the fragment that they referred to as a "booster tube" (Figure 8). In an undamaged inflator, the booster tube would be located in the area of the metal cap, and it would be inserted into the base. A vehicle history report in which the most recent record was July 2018 included no record of any air bag service or replacement. Damage to the air bag and related data is discussed further in the Supplemental Restraints System section of this report.

Figure 7. Ruptured air bag inflator, the 2004 BMW 325i

Figure 8. Air bag inflator "booster tube" fragment, the 2004 BMW 325i

NHTSA Recalls and Investigations

A search queried in January 2022 using the BMW's VIN revealed two incomplete recalls and one investigation.

On May 17, 2015, NHTSA Recall Number 15V318 was issued concerning the driver's frontal air bag. The summary, safety risk, and remedy details were similar to those of the passenger's frontal air bag recall.

On July 15, 2014, NHTSA Recall Number 14V428 was issued concerning the passenger's frontal air bag. In summary, on certain BMW model year 2000–2006 3 Series sedans, coupes, and convertibles, the passenger's frontal air bag may produce excessive internal pressure that could cause the inflator to rupture upon deployment of the air bag. The safety risk was such that in the event of a ruptured inflator, metal fragments could potentially strike and seriously injure the front passenger or other occupants. To remedy the issue, the OEM would replace the passenger's frontal air bag module free of charge at an authorized OEM service center.

The search revealed the NHTSA Investigation EA15-001, which was opened on February 24, 2015, following consumer complaints identifying Takata airbag inflator ruptures. In summary, the inflators may rupture during driver and/or passenger frontal air bag deployment, resulting in metal fragments being propelled into the passenger compartment.

2004 BMW 325i Occupant

Driver Demographics

Age/sex:	16 years/male
Height:	175 cm (69 in)
Weight:	90 kg (198 lb)
Eyewear:	Unknown
Seat type:	Bucket with adjustable head restraint
Seat track position:	Between middle and full rearward
Manual restraint usage:	Lap and shoulder seat belt not used
Usage source:	Vehicle inspection, medical records, and driver statement
Air bags:	Frontal air bag deployed; door-mounted side impact air bag did not deploy
Alcohol/drug data:	None
Egress from vehicle:	Exited without assistance through left side door
Transport from scene:	Ambulance to hospital
Type of medical treatment:	Declared deceased in emergency department

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Laceration NFS, inferior vena cava	521202.3	Air bag inflator fragment	Certain
2	Laceration NFS, stomach	544420.2	Air bag inflator fragment	Certain
3	Laceration NFS, small bowel	541499.2	Air bag inflator fragment	Certain
4	Laceration NFS, liver	541820.2	Air bag inflator fragment	Certain
5	Laceration NFS, right kidney	541620.2	Air bag inflator fragment	Certain
6	Laceration, abdomen (4 x 2 cm, gaping)	510602.1	Air bag inflator fragment	Certain
7	Laceration NFS, right psoas muscle	510600.1	Air bag inflator fragment	Certain
8	Laceration, chin, minor (3.5 cm, jagged)	210602.1	Air bag inflator fragment	Probable
9	Abrasions, upper chest	410202.1	Frontal air bag	Probable
10	Abrasions, face	210202.1	Frontal air bag	Probable

Source: medical records, autopsy.

Driver Kinematics

The unbelted 16-year-old male driver was seated in an unknown posture. At impact with the Toyota, the BMW driver's frontal air bag deployed and the inflator ruptured, causing a metal fragment to tear and pass through the air bag fabric. The driver was displaced forward in response to the 1 o'clock direction of force, likely loading the deployed air bag with his face,

head, chest, and abdomen. The loose metal fragment contacted the driver's abdomen, causing penetrating lacerations to the abdomen, stomach, small bowel, liver, right kidney, inferior vena cava, and right psoas muscle, with extensive, associated intra-abdominal hemorrhage involving roughly 2,000 mL of peritoneal blood loss. His face sustained abrasions to the left cheek, lower lip, lower chin, and upper chest.

The BMW traveled a short distance and came to rest on the roadway. The driver remained conscious and exited the vehicle without assistance through the left side door. According to a witness, he soon collapsed to the ground. Police photos indicated that the driver left blood deposits on the vehicle interior, areas of the exterior, and on the roadway. Following the arrival of emergency responders, the driver was transported by ambulance to a local hospital. During his transport, his condition worsened. After arriving at the hospital, he was declared deceased in the emergency department following unsuccessful resuscitative efforts. During the autopsy, an air bag inflator fragment was recovered from the soft tissue of the driver's back. According to the autopsy report, the cause of death was penetrating abdominal trauma, the manner of death was accidental, and the injury occurred as a result of the driver being involved in a vehicle collision.

2018 Toyota Corolla

Description

The 2018 Toyota Corolla was identified by the VIN 2T1BURHE4JCxxxxxx. The vehicle's VIN placard was not accessible due to jammed doors; a VIN search revealed an order date of November 2017 and a date of first use of February 2018. The Toyota was a 4-door sedan configured for five passengers. It was equipped with a 1.8-liter, 4-cylinder gasoline engine; a front-wheel drive; an automatic transmission; power steering and brakes; antilock brakes; a tilt and telescoping steering functionality; power windows; and a power moon roof. The vehicle manufacturer recommended size P205/55R16 tires for the front and rear. It had Toyo Proxes 4 Plus tires of the recommended size manufactured in 2017 on the front, and Toyo Extensa tires of the recommended size manufactured in 2019 on the rear.

Exterior Damage

The Toyota sustained direct and induced damage to the left plane during the impact with the BMW. Direct damage to the left plane measured at mid-door level began at the left rear bumper corner and extended 230 cm (90.6 in) ending 50 cm (19.7 in) aft of the left A-pillar. The Field L began at the left C-pillar and extended 179 cm (70.5 in) ending 50 cm (19.7 in) aft of the left A-pillar. Twenty measurements were taken at mid-door level using the Nikon total station, and the Faro Blitz tool calculated six crush measurements as follows: C_1=3 cm (1.2 in), C_2=5 cm (2.0 in), C_3=7 cm (2.7 in), C_4=8 cm (3.1 in), C_5=5 cm (2.0 in), and C_6=1 cm (0.4 in). Maximum crush was located on the second row left door panel at 10 cm (3.9 in) aft of the B-pillar, and the CDC for the Toyota in Event 1 was 09LZEW1 (Figure 9).

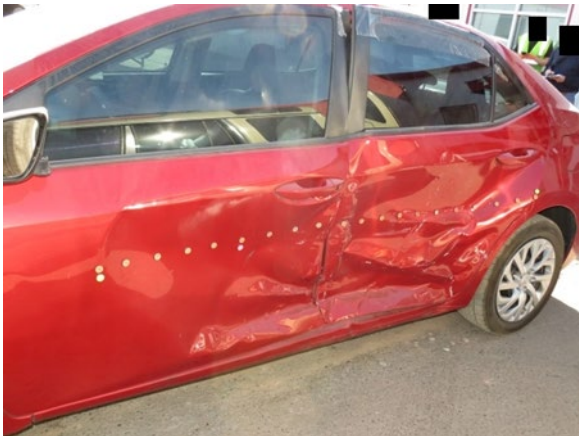
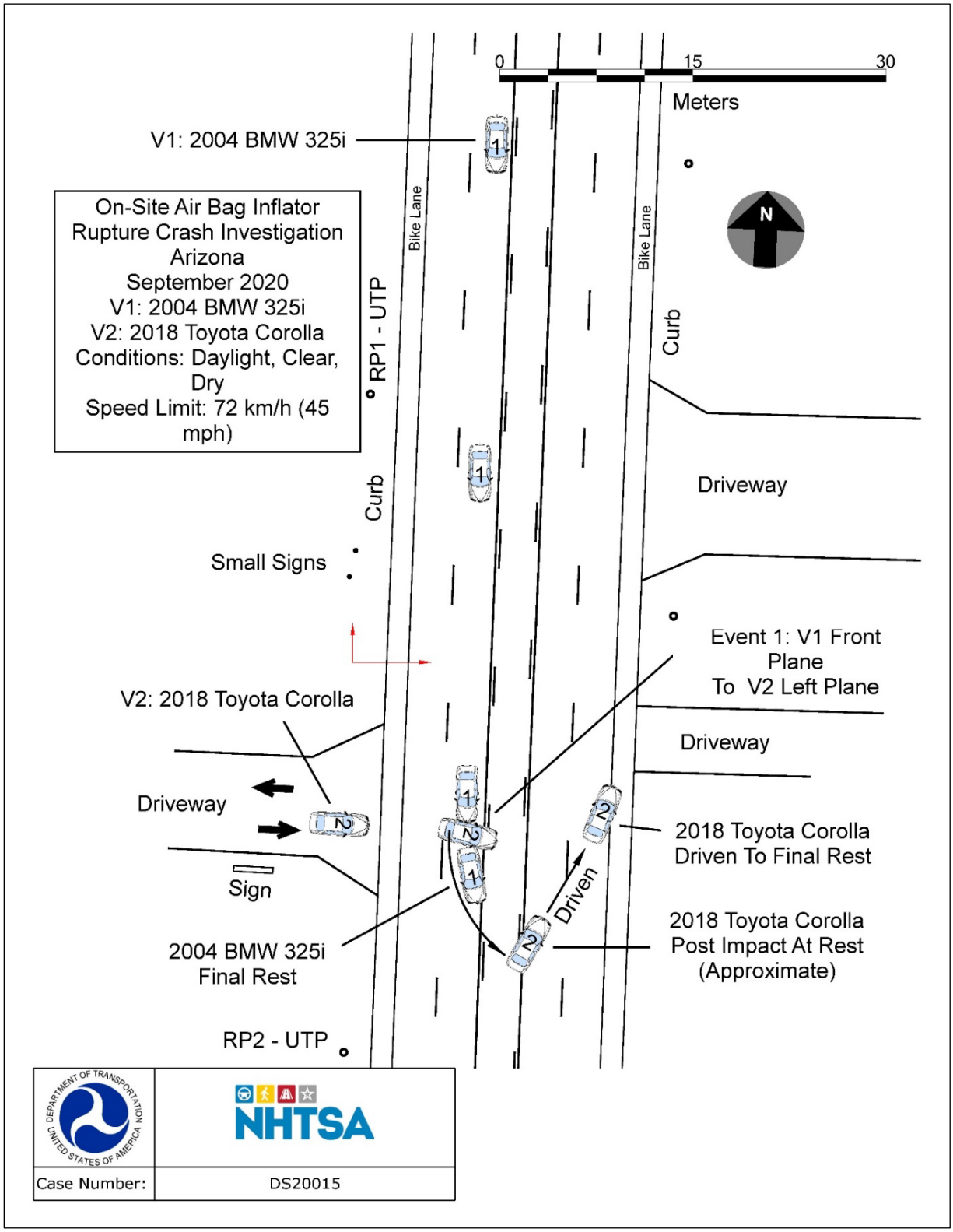


Figure 9. Left plane damage, the 2018 Toyota Corolla

Occupant Data

The Toyota was driven by a 26-year-old male. According to the police report, he was belted and not injured or transported.

Crash Diagram



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**National Highway
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