CRASH DATA RESEARCH CENTER
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CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
CALSPAN CASE NO: CA08025

VEHICLE: 2008 SUBARU B9 TRIBECA
LOCATION: PENNSYLVANIA
CRASH DATE: MAY 2008

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract This investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in 2008 Subaru B9 Tribeca and the injury sources to the 21-year-old female driver. A CAC vehicle is certified by the vehicle manufacturer to be compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This advanced occupant protection system was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switch sensors, front safety belt pretensioners, and a front right occupant detection sensor. The Subaru was also equipped with combination rollover/side impact Inflatable Curtain (IC) air bags and seat-mounted side impact air bags. The Subaru was involved in an offset frontal crash with a 1996 Oldsmobile Cutlass Supreme. The crash occurred when the eastbound Oldsmobile failed to maintain its proper lane through a right curve, crossed the centerline and impacted a guardrail located outboard the westbound lane. The Oldsmobile was then deflected back into the westbound lane directly into the path of the westbound Subaru. The frontal area of the Oldsmobile impacted the left aspect of the Subaru's front plane. The force of the impact caused the CAC driver air bag and the left IC air bag to deploy in the Subaru. The restrained 21-year-old female driver of the Subaru sustained police reported minor injuries and was transported via ground ambulance to a local hospital.			
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BACKGROUND

This investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in 2008 Subaru B9 Tribeca **(Figure 1)** and the injury sources to the 21-year-old female driver. A CAC vehicle is certified by the vehicle manufacturer to be compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This advanced occupant protection system was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switch sensors, front safety belt pretensioners, and a front right occupant detection sensor. The Subaru was also equipped with combination rollover/side impact Inflatable Curtain (IC) air bags and seat-mounted side impact air bags.

Figure 1: Left front oblique view of the 2008 Subaru Tribeca.

The Subaru was involved in an offset frontal crash with a 1996 Oldsmobile Cutlass Supreme. The crash occurred when the eastbound Oldsmobile failed to maintain its proper lane through a right curve, crossed the centerline and impacted a guardrail located outboard the westbound lane. The Oldsmobile was then deflected back into the westbound lane directly into the path of the westbound Subaru. The frontal area of the Oldsmobile impacted the left aspect of the Subaru's front plane. The force of the impact caused the CAC driver air bag and the left IC air bag to deploy in the Subaru. The restrained 21-year-old female driver of the Subaru sustained police reported minor injuries and was transported via ground ambulance to a local hospital.

This crash was identified by the Crash Investigation Division of the National Highway Traffic Safety Administration through police reported crashes sampled by the General Estimates System (GES). The crash information was forwarded to the Calspan Special Crash Investigations (SCI) team for follow-up on June 24, 2008. The Subaru was deemed a total loss by the insurance company and was moved to a salvage facility. Cooperation was established with the salvage facility to inspect the Subaru. An on-site investigation of the crash was assigned to the Calspan SCI team on June 24, 2008 due to the agency's interest in vehicles equipped with CAC safety systems and the Subaru was inspected on June 26, 2008. The driver of the Subaru was contacted via telephone; however, she refused to participate in this safety research. The Oldsmobile could not be located and was not inspected for this on-site investigation.

SUMMARY

VEHICLE DATA

2008 Subaru B9 Tribeca

The 2008 Subaru B9 Tribeca was identified by the Vehicle Identification Number (VIN): 4S4WX92D584 (production sequence deleted). The odometer reading, obtained from the insurance carrier, was 13,867 km (8,618 miles) at the time of the crash. The Subaru was a four-door, sport utility vehicle that was equipped with a 3.6-liter, six-cylinder engine, five-speed automatic transmission, all-wheel drive, power front and rear disc brakes with antilock and brake assist. The Subaru was also equipped with traction control and stability control as standard features. The vehicle was equipped with Goodyear Eagle LS 2 tires, size P255/55R18 mounted on OEM alloy wheels. The vehicle manufacturer recommended cold tire pressure was 221 kPa (32 PSI) front and rear. The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Tire flat	7 mm (9/32)	No	Cut side wall and rim fractured
LR	228 kPa (33 PSI)	7 mm (9/32)	No	None
RF	221 kPa (32 PSI)	7 mm (9/32)	No	None
RR	221 kPa (32 PSI)	7 mm (9/32)	No	None

The Subaru was configured with leather upholstered five passenger seating. The front bucket seats were equipped with height adjustable head restraints. At the time of the SCI inspection, the front left head restraint was adjusted 9 cm (3.5 in) above the full-down position. The front right head restraint was adjusted 4 cm (1.7 in) above the full-down position. The second row was configured with a three-passenger split bench seat with height adjustable head restraints adjusted to the full-down positions.

1996 Oldsmobile Cutlass Supreme

The 1996 Oldsmobile Cutlass Supreme contained the following VIN: 1G3WH52MXTF (production number omitted). Based on the VIN, the Oldsmobile was a four-door sedan that was powered by a 3.1-liter, V6 engine, and four-speed automatic transmission with front-wheel drive. It was equipped with manual safety belts and a frontal air bag system. This vehicle could not be located and was not inspected.

CRASH SITE

This off-set frontal crash occurred during the morning hours of May 2008 on a two-lane, two-way east/west roadway. At the time of the crash, it was raining and the asphalt road surface was wet. The impact occurred approximately 24 m (80 ft) beyond the end of a 115 m (377 ft) radius right curve for eastbound traffic. The travel lanes measured 3.6 meters (11.8 feet) in width and were separated by a double-yellow centerline. The north road edge was bordered by a 1.2 meter (3.9 feet) shoulder and a W-beam guardrail. The south roadside consisted of a steep positive grade embankment that consisted of vegetation and trees. The posted speed limit for the roadway was 40 km/h (25 mph). A schematic of the crash is included as **Figure 11** of this report.

CRASH SEQUENCE

Pre-Crash

The 21-year-old female driver of the Subaru was operating the vehicle westbound on the two-lane road in a straight section of the road approaching the curve **(Figure 2)**. A 42-year-old male was operating the 1996 Oldsmobile in the eastbound lane negotiating the right curve **(Figure 3)**. The driver of the Oldsmobile drove straight through the curve, crossed the centerline, and entered the westbound lane. The driver of the Subaru reacted to the errant trajectory of the Oldsmobile by applying the brakes.

Figure 2: Westbound trajectory view of the Subaru.

Figure 3: Eastbound trajectory view of the Oldsmobile.

Crash

As it exited the curve, the left frontal aspect of the Oldsmobile impacted the W-beam guardrail system that bordered the north road edge (Event 1). The guardrail impact deflected the Oldsmobile back to its right into the westbound lane. During this trajectory, the front left corner of the Oldsmobile impacted the front left aspect of the Subaru (Event 2). The Subaru driver reported to the investigating officer that she was stopped at the time of the impact. The direction of force for the Subaru was within the 12 o'clock sector. The force of the impact resulted in the actuation of the Subaru's front safety belt pretensioners and the deployment of the driver's frontal air bag and the left IC air bag. The off-set impact configuration induced a counterclockwise rotation to the Subaru. The Subaru rotated approximately 20 degrees and came to rest within the westbound travel lane. The Oldsmobile rotated clockwise approximately 130 degrees and came to rest in the eastbound lane.

The missing vehicle algorithm of the WinSMASH program was used calculate the severity (delta-V) of the impact. The total calculated delta-V for the Subaru was 13.0 km/h (8.1 mph). The Subaru's longitudinal and lateral delta-V components were -12.8 km/h (-8.0 mph) and -2.3 km/h (-1.5 mph), respectively. The total calculated delta-V for the Oldsmobile was 17.0 km/h (10.6 mph) with longitudinal and lateral components of -17.0 km/h (-10.6 mph) and 0 km/h.

Post-Crash

Police and Emergency Medical Services (EMS) personnel responded to the crash site. The driver of the Subaru sustained minor severity injuries and was transported via ground ambulance

to a local hospital. The driver of the Oldsmobile was reported as sustaining severe injuries. Both vehicles sustained disabling damage and were towed from the crash site. The Subaru was subsequently declared a total loss by the insurance company.

2008 SUBARU B9 TRIBECA

Exterior Damage

The 2008 Subaru B9 Tribeca sustained moderate severity frontal damage as result of the impact with the Oldsmobile **(Figures 4 and 5)**. The damaged components included, but were not limited, to the front bumper fascia, bumper beam, upper radiator support, left headlight assembly, left fender, and the left front suspension components. During the crash sequence, the front of the Oldsmobile engaged the Subaru's front left corner, outboard of the bumper reinforcement beam. As the vehicles crushed, the Oldsmobile remained engaged with the left side Subaru which resulted in contact to the left front wheel assembly. This contact resulted in a fracture of the left front ball joint and lower control arm.

Figure 4: Overall view of the Subaru's frontal damage.

The front bumper fascia exhibited direct contact damage that began 36 cm (14 in) left of the vehicle centerline and extended 41 cm (16 in) to the front left corner. The maximum frontal crush which measured 4 cm (1.6 in) was documented at the left corner of the bumper beam. A crush profile that was comprised of six equidistant points was documented along the reinforcement beam and was as follows: C1 = 4 cm (1.6 in), C2 = 4 cm (1.6 in), C3 = 4 cm (1.6 in), C4 = 2 cm (0.8 in), C5 = 0 cm, C6 = 0 cm.

Figure 5: Left lateral view of the Subaru.

The Collision Deformation Classification (CDC) for this impact was 12-FLEE5. The left front door was jammed in the closed position. The right front, rear, and the hatch remained closed during the crash and were operational at the time of the SCI inspection. The windshield was fractured at the lower left aspect. The front side door glazing contained an aftermarket tint film. The side, rear, and sunroof were found closed and undamaged at the time of the SCI inspection.

Interior Damage

Inspection of the passenger compartment of the Subaru revealed minor damage associated with occupant contact points. The contact points consisted of two faint scuffs to the driver's knee

bolster **(Figure 6)**. The first scuff was located 19 cm (7.5 in) left of the steering column centerline and measured 8 cm (3 in) in length. A second scuff was located 6 cm (2.5 in) right of the steering column centerline. This scuff measured 3 cm (1 in) n length and 4 cm (1.5 in) in width. There was no intrusion or interior damage associated with the exterior crash force.

Figure 6: Knee bolster contact points.

The driver's bucket seat was adjusted to a mid-track position. The driver's seat back was reclined 20 degrees aft of vertical. The horizontal distance from the seat back to the center of the steering wheel rim measured 64 cm (25 in). The tilt steering column was located in the center position. There was no deformation of the steering wheel rim. There was 1 cm (0.5 in) of steering column shear capsule compression.

Air Bag System

Certified Advanced 208-Compliant Safety System

The Subaru was equipped with a CAC frontal safety system. A CAC vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The system consisted of dual stage frontal air bags, an occupant presence detection sensor for the front right seat, seat track position sensors, safety belt buckle switch sensors to monitor belt usage, and safety belt pretensioners.

As a result of the crash, the driver's frontal air bag deployed **(Figure 7)**. The driver's air bag was conventionally located in the center of the steering wheel hub and was concealed by three cover flaps. The top cover flap measured 8 cm (5 in) in height and width. The symmetric lower cover flaps measured 7 cm (2.8 in) in height and 6 cm (2.5 in) in width. The air bag measured 61 cm (24 in) in diameter in its deflated state. It was tethered by two straps and was vented by two ports at the 10 and 2 o'clock positions. There was no damage or occupant contact evidence present on the air bag. Dirt was noted on the lower right quadrant of the bag.

Figure 7: Driver's frontal air bag.

The front right passenger air bag was a top-mount design located in the right aspect of the instrument panel. The front right position was unoccupied at the time of the crash; therefore, the front right air bag deployment was suppressed at the time of the impact

Side Impact Air Bag System and Rollover Crash Protection System

The Subaru was equipped with seat-mounted side impact air bags for the front seats and side impact/rollover IC air bags for the outboard seating positions. As a result of the crash, the left IC air bag deployed **(Figure 8)**. The air bag was rectangular in shape and measured 165 cm (65 in) in length. The height of the curtain air bag membrane measured 46 cm (18 in) and it extended 5 cm (2 in) below the belt line at the front left position. The height of the curtain air bag membrane provided head protection from the roof side rail to belt line of the vehicle.

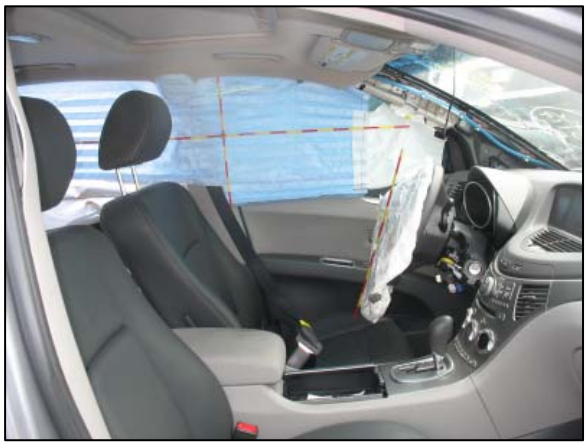

Figure 8: Deployed left side curtain air bag.

A sail panel was attached to the forward aspect of the air bag and coverage the void created at A-pillar junction. The panel was trapezoidal in shape and measured 15 cm (6 in) in height and 31 cm (12 in) in width. The IC air bag was free of crash related damage and occupant contact points. The front left aspect of the curtain air bag had been cut post-crash.

Manual Restraint Systems

The Subaru was equipped with manual 3-point lap and shoulder safety belts for the five seating positions. The driver's safety belt was configured with continuous loop webbing, a sliding latch plate, a height adjustable D-ring that was located 2 cm (0.8 in) above the full-down position at the time of the SCI inspection, an Emergency Locking Retractor (ELR), and a retractor mounted pretensioner.

The driver utilized the safety belt during the crash, as evidenced by frictional abrasions on the latch plate, a transfer on the webbing, and actuation of the retractor pretensioner. The actuation of the retractor pretensioner locked a 165 cm (65 in) section of the safety belt webbing in the used position. The combination of the driver loading the safety belt and the actuation of the pretensioner resulted in a 5 cm (2 in) transfer on the webbing. This transfer was located 79 cm (31 in) above the floor anchor at the latch plate interface.

The front right safety belt was configured with continuous loop webbing, a sliding latch plate, a height adjustable D-ring, retractor pretensioner, and a switchable ELR/Automatic Locking Retractor (ALR). The second row safety belts were configured with continuous loop webbing, sliding latch plates and switchable ELR/ALR retractors. The front right and rear seats were not occupied during the crash.

DRIVER DEMOGRAPHICS

Age/Sex:	21-year-old/Female
Height:	Unknown

Weight:	Unknown
Seat Track Position:	Mid-track
Safety belt usage:	3-point manual lap and shoulder safety belt
Usage Source:	Vehicle inspection
Egress from Vehicle:	Unassisted
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Treated and released

Driver's Injuries

Injury	Injury Severity (AIS Update 98)	Injury Source
Cervical (neck) strain	Minor (640278.1,6)	Crash force
Left neck contusion	Minor (390402.1,2)	Safety belt
Left shoulder abrasion	Minor (790202.1,2)	Safety belt
Left shoulder contusion	Minor (790402.1,2)	Safety belt
Chest wall contusion	Minor (490402.1,9)	Safety belt
Bilateral hip abrasions (small in size, over each iliac crest)	Minor (890202.1,3)	Safety belt
Right knee small abrasion	Minor (890202.1,1)	Knee bolster

Source = Medical records

Driver Kinematics

The 21-year-old female driver of the Subaru was seated in an upright posture with the seat track adjusted to a mid-track position and was restrained by the lap and shoulder belt. At impact with the Oldsmobile, the retractor pretensioner actuated, the frontal air bag, and the left IC air bag deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of force and loaded the safety belt. The loading of the safety belt resulted in the left neck contusion, the left shoulder abrasion and contusion, the chest wall contusion and the bilateral hip abrasions. Her knees contacted the knee bolster evidenced by the right knee contusion and the scuff marks to the bolster panel. The deployed frontal air bag prevented potential face/head contact with the steering wheel. As the driver rode down the force of the crash, her head/neck flexed forward over the safety belt resulting in the cervical strain. She then rebounded back into her seat and came to rest. The driver exited the vehicle unassisted through the front right door and waited for the first responders. She was subsequently transported by ground ambulance to a local hospital for examination and treatment of her injuries.

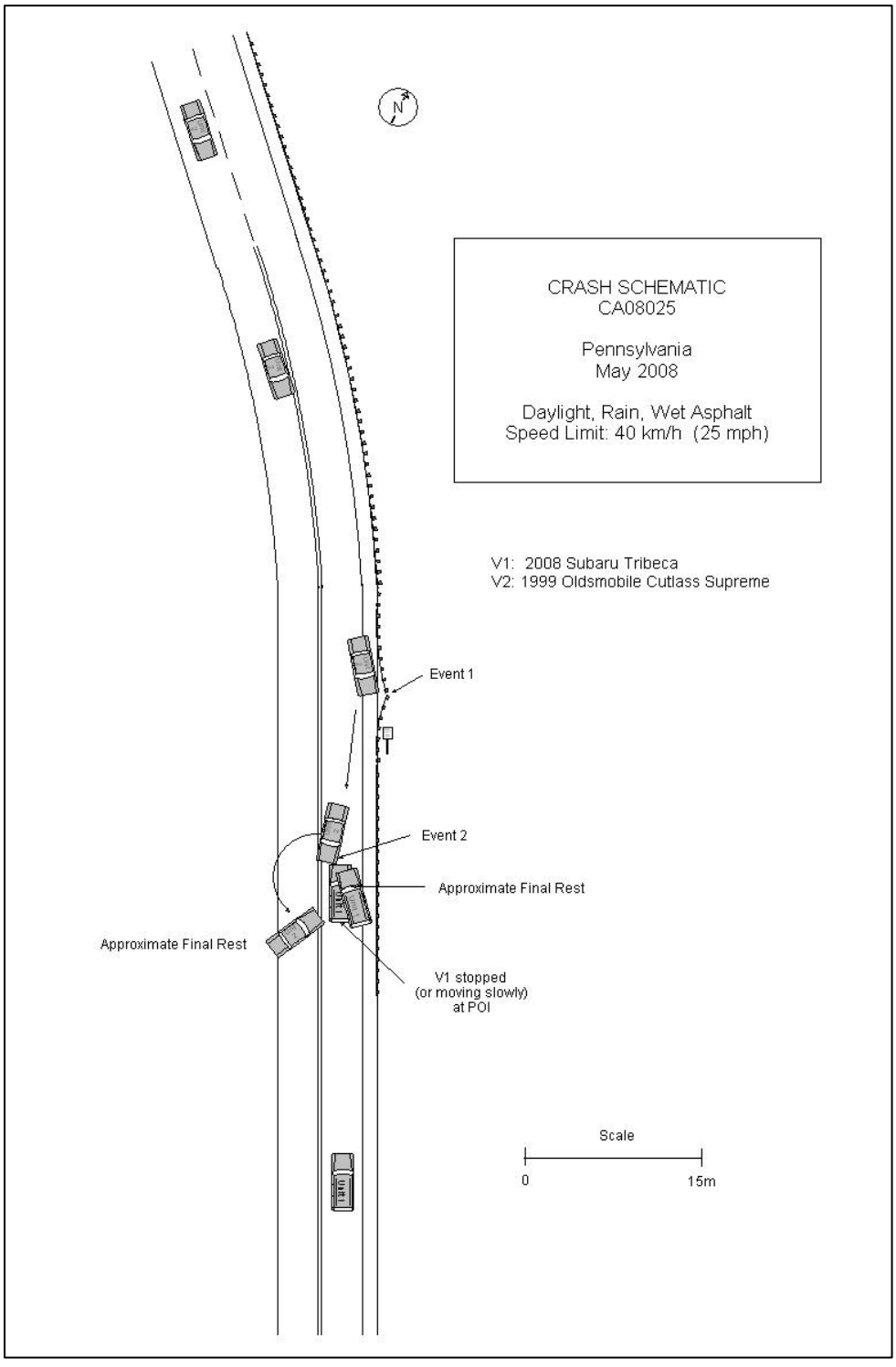

Figure 9: Crash schematic.