

Certified Advanced 208-Compliant Air Bag/Rollover Investigation
Dynamic Science, Inc. / Case Number: DS06031
2006 Subaru Impreza
Colorado
November 2006

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

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

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16. Abstract This on-site investigation focused on a 2006 Subaru Impreza that was involved in a rollover crash. The Impreza was occupied by a 19-year-old male. The other vehicle is a 2006 Chevrolet Cobalt that was being driven by a 23-year-old male. The case vehicle was traveling westbound on an interstate highway. The other vehicle was traveling at a slower speed in front of the case vehicle. The driver of the case vehicle apparently did not see the other vehicle until it was too late. The front of the case vehicle struck the rear of the other vehicle. The case vehicle began a counterclockwise rotation after the impact. The case vehicle left the roadway on the right. The case vehicle tripped after leaving the roadway and began a right side leading rollover. The case vehicle rolled 3-1/2 times before coming to rest on its roof. The other vehicle went into a counterclockwise yaw after the impact. The other vehicle left the roadway on the left and came to rest on its wheels in the median. The driver of the Impreza sustained a concussion, a left clavicle fracture, a lung contusion, a left wrist fracture, a left ulna fracture, and multiple lacerations/contusions/abrasions. He was transported to a local hospital where he was hospitalized for three days.				
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Dynamic Science, Inc.
Crash Investigation
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BACKGROUND

This on-site investigation focused on a 2006 Subaru Impreza that was involved in a rollover crash. The Impreza was occupied by a 19-year-old male. The other vehicle is a 2006 Chevrolet Cobalt that was being driven by a 23-year-old male. The case vehicle was traveling westbound on an interstate highway. The other vehicle was traveling at a slower speed in front of the case vehicle. The driver of the case vehicle apparently did not see the other vehicle until it was too late. The front of the case vehicle struck the rear of the other vehicle. The case vehicle began a counterclockwise rotation after the impact. The case vehicle left the roadway on the right. The case vehicle tripped after leaving the roadway and began a right side leading rollover. The case vehicle rolled 3-1/2 times before coming to rest on its roof. The other vehicle went into a counterclockwise yaw after the impact. The other vehicle left the roadway on the left and came to rest on its wheels in the median. The driver of the Impreza sustained a concussion, a left clavicle fracture, a lung contusion, a left wrist fracture, a left ulna fracture, and multiple lacerations/contusions/abrasions. He was transported to a local hospital where he was hospitalized for three days.



Figure 1. 2006 Subaru Impreza



Figure 2. Exemplar view of 2006 Subaru Impreza

This Certified Advanced 208-Compliant Air Bag/Rollover case was identified by NHTSA during a review of police reports. DSI was faxed the report on December 12, 2006. DSI located the case vehicle and obtained permission to inspect the vehicle on December 14, 2006. DSI was assigned the case on December 15, 2006. The case vehicle was inspected on December 28, 2006. The scene was not inspected during this trip due to blizzard conditions and road closures.

SUMMARY

Crash Site

This two vehicle crash occurred on a three-lane divided interstate highway in November 2006 at 2355 hours. At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface was dry. It was dark at the time of the crash and there were no streetlights present. The posted speed limit is 105 km/h (65 mph).

Pre-Crash

The case vehicle was traveling westbound in the middle lane at a police estimated speed of 137 km/h (85 mph). DSI calculated the minimum travel speed to be 130 km/h (81 mph), based on post-impact skidding on and off the roadway. The other vehicle was traveling at a slower speed in front of the case vehicle. The driver of the case vehicle apparently did not see the other vehicle until it was too late.

Crash

The case vehicle's front end then collided with the other vehicle's rear end. The missing vehicle routine of the WinSmash program computed a total delta V of 22.0 km/h (13.7 mph), based on the Impreza's front end crush profile. The longitudinal and lateral components were -22.0 km/h (-13.7 mph) and 0 km/h (0 mph), respectively. The frontal air bags in the Impreza did not deploy.

The case vehicle began a counterclockwise rotation after the impact and skidded for 40 m (130 ft). The case vehicle left the roadway on the right. The case vehicle tripped after leaving the roadway and began a right side leading rollover. The vehicle impacted a sign with its right side after completing its first four quarter rollover and traveling 28 m (92 ft). The case vehicle rolled 2-1/2 more times while traveling 50 m (163 ft) before coming to rest on its roof facing generally east. The other vehicle went into a counterclockwise yaw after the impact and departed the roadway on the left before coming to rest on its wheels in the median.

Post-Crash

The driver of the Impreza sustained a concussion, a left clavicle fracture, a lung contusion, a left wrist fracture, a left ulna fracture, and multiple lacerations/contusions/abrasions. He was transported to a local hospital where he arrived with a Glasgow Coma Scale (GCS) score of 13. He was admitted and hospitalized for three days. The driver of the other vehicle did not report any injuries.

Both vehicles were towed from the scene due to damage. The case vehicle was placed on a police hold.

VEHICLE DATA -2006 Subaru Impreza

The 2006 Subaru Impreza was identified by the Vehicle Identification Number (VIN: JF1GD676X6Gxxxxxx). The vehicle's odometer could not be read since there was no power. The Impreza was a four-door sedan that was equipped with a 2.5 liter, four-cylinder engine, all wheel drive, 4-wheel anti-lock brakes, front and rear disc brakes with electronic brake force distribution, a manual transmission, power steering and a tilt steering wheel. The Impreza was configured with Bridgestone Potenza P205/55R16 tires. The manufacturer's recommended tire pressure was 221 kPa (32 psi) for the front and 228 kPa (33 psi) for the rear. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	165 kPa (24 psi)	9 mm (11/32 in)	Yes	Scuffing on rim
LR	Flat	10 mm (12/32 in)	No	Debeaded
RR	179 kPa (26 psi)	9 mm (11/32 in)	No	Canted to left
RF	Flat	9 mm (11/32 in)	No	Canted to left

The seating in the Impreza was configured with fabric covered front bucket seats with adjustable head restraints and a rear bench seat. Both front seats were in the full rearward track position. The driver's seat back angle was 19 degrees from vertical and the seat bottom angle was 14 degrees from horizontal. The front right passenger seat back angle was 30 degrees from vertical and the seat bottom angle was 14 degrees from horizontal. The driver's seat had an after market seat cover on at the time of the vehicle inspection.

VEHICLE DAMAGE

Exterior Damage - 2006 Subaru Impreza

The 2006 Subaru Impreza sustained moderate frontal damage as a result of the impact with the rear of the Chevrolet Cobalt. The direct damage began at the left front bumper corner and extended 29.0 cm (11.4 in) laterally across the front of the bumper. The direct damage extended 89.0 cm (35.0 in) rearward along the left side plane. The left wheelbase was shortened by 8.0 cm (3.1 in). Six crush measurements were documented at the bumper level: C1 = 29.0 cm (11.4 in), C2 = 8.0 cm (3.1 in), C3 = 17.0 cm (6.7 in), C4 = 12.0 cm (4.7 in), C5 = 0 cm (0 in), C6 = 0 cm (0 in).

The Collision Deformation Classification (CDC) for the impact with the Cobalt was 12FLEE5.

There was direct contact damage along the left side plane, right side plane, on the roof near the windshield header and along the left roof rail that occurred during the vehicle rollover. There was 5.0 cm (1.9 in) of vertical crush and 9.0 cm (3.5 in) of lateral crush at the left A pillar. There was 20.0 cm (7.9 in) of vertical crush at the windshield header. There was 47.0 cm (18.5 in) of lateral crush at the left rear quarter panel. The trunk lid opened during the crash and the rear bumper fascia had come off. The right rear tire and right front tire were canted to the left from lateral loading. The CDC for the rollover was 00TDDO3.

It has been reported that during the rollover sequence the case vehicle struck a roadside pole with its right side. It is not clear where the pole was impacted and what kind of pole was involved. There is some damage above the right rear wheel that might be related to a pole impact. An unknown CDC of 99R99999 was assigned to this impact.



Figure 3. Left front bumper corner damage, Subaru Impreza



Figure 4. Left side damage, Subaru Impreza



Figure 5. Right side damage, Subaru Impreza

Delta V (Impact 1):	Total	22.0 km/h (13.7 mph)
	Longitudinal	-22.0 km/h (-13.7 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	22,189 joules (16,366 ft lbs)



Figure 6. Overview of roof crush

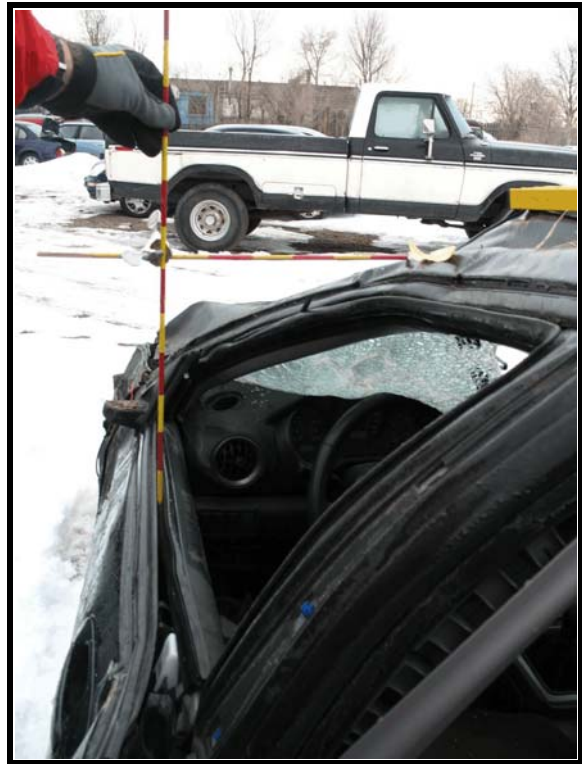


Figure 7. Left side A pillar crush

Interior Damage - 2006 Subaru Impreza

The Subaru Impreza sustained moderate interior damage as a result of passenger compartment intrusion. The left side roof, roof rail, and A pillar sustained vertical intrusion. Both right side doors were jammed shut. Side glass for the right and left side windows was disintegrated. The backlight was also disintegrated. The windshield was damaged during the rollover. At the time of inspection, there was a gap between the windshield header and the glass, but this may have been related to sag. There was blood found on the interior roof in a dropping type pattern. There was a smeared blood stain on the left hand rail. The driver's seat belt had been cut by EMS personnel. There were loading marks located on the seat belt webbing.

The specific passenger compartment intrusions were documented as follows:



Figure 8. Blood stain pattern and left A pillar movement

Position	Intruded Component	Magnitude of Intrusion	Direction
LF	A pillar	18.0 cm (7.0 in)	Lateral
LR	Roof rail	17.0 cm (6.7 in)	Vertical
LF	Windshield header	13.0 cm (5.1 in)	Vertical
RR	C pillar	12.0 cm (4.7 in)	Vertical
RF	A pillar	10.0 cm (3.9 in)	Vertical
LR	Backlight header	9.0 cm (3.5 in)	Vertical
LF	Roof rail	7.0 cm (2.8 in)	Vertical
LF	Roof	3.0 cm (1.2 in)	Vertical
LF	A pillar	3.0 cm (1.2 in)	Vertical

Manual Restraints - 2006 Subaru Impreza

The 2006 Subaru Impreza was configured with manual 3-point lap and shoulder belts for each of the five seating positions. Both front seat safety belts were equipped with retractor pretensioners and adjustable D rings that were in the full down position. The pretensioners did not actuate during the crash. Both rear outboard seats were also equipped with adjustable D rings that were in the full down position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). Rescue personnel had cut the webbing. There were indications of loading on the webbing.

The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR).



Figure 9. Driver's seat belt

Supplemental Restraint Systems - 2006 Subaru Impreza

The Subaru Impreza was configured with a Certified Advanced 208-Compliant (CAC) air bag system. A CAC vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Impreza was also configured with seat mounted front side air bags with head protection. These are head/chest combination air bags that are designed to help protect both the head and chest of an adult in side impacts.

The frontal air bags did not deploy. The front right passenger's side air bag did deploy—possibly due to the pole impact. The air bag deployed vertically from the seat back. The air bag measured 55.0 cm (21.7 in) high by 24.0 cm (9.4 in) wide. There were two vent ports on the outside and two vent ports on the inside.

The driver's side air bag did not deploy. The seat back was covered by an after market seat cover, but there were no indications that the cover had any effect on the air bag.

There were no indications of contact or damage to the air bag. This seat location was unoccupied.



Figure 10. Front right passenger side air bag (exterior view)

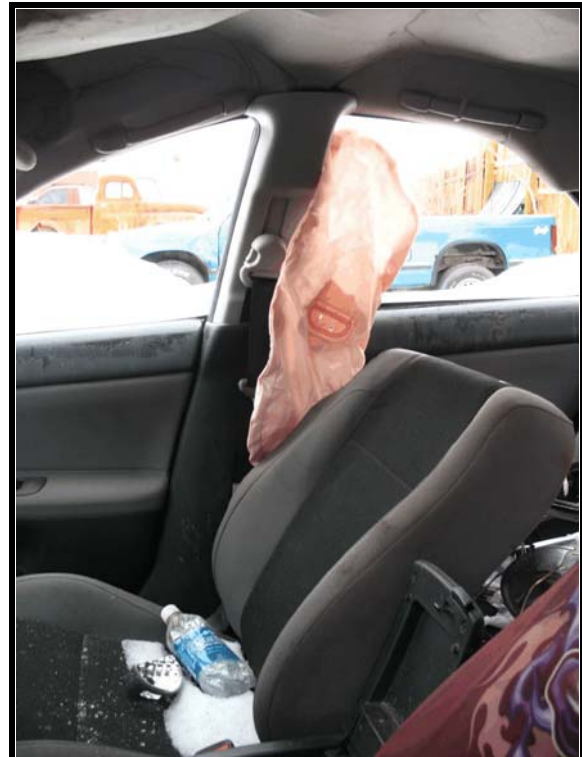


Figure 11. Front right passenger side air bag (interior view)

VEHICLE DATA - 2006 Chevrolet Cobalt

Description:	2006 Chevrolet Cobalt two door coupe	
VIN:	1G1AK15F167xxxxxx	
Odometer:	Unknown	
Engine:	2.2 liter, four cylinder	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Moderate right front and right rear damage, per police report.	
CDC:	Unknown	
Delta V:	Total	24.0 km/h (14.9 mph)
	Longitudinal	24.0 km/h (14.9 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	36,688 joules (27,060 ft lbs)

OCCUPANT DEMOGRAPHICS - 2006 Subaru Impreza

	Driver
Age/Sex:	19/Male
Seated Position:	Front left
Seat Type:	Bucket seat
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Normal, upright
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted frontal air bag, did not deploy. Seat back mounted side air bag, did not deploy.

OCCUPANT DEMOGRAPHICS - 2006 Chevrolet Cobalt

Age/Sex:	23/Male
Seated Position:	Front left
Seat Type:	Bucket
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Right foot presumed to be on accelerator, left on floor
Restraint Usage:	Lap and shoulder belt used, per police report

OCCUPANT INJURIES -2006 Subaru Impreza

Driver: Injuries obtained from ER Records, Operative Report and Radiology Records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Lethargic, Stuporous, Obtunded on Admission or Initial Observation at Scene; unconsciousness known to be less than one hour	160610.2,0	B pillar	Possible
Multiple abrasions, scalp	190202.1,9	B pillar	Possible
Contusions, bilateral, periorbital area	290402.1,1 290402.1,2	Unknown	Unknown
Fracture, left clavicle	752200.2,2	Seat belt webbing	Probable
Contusion, right lung, with pneumothorax	441406.3,1	Unknown	Unknown
Fracture, open, comminuted, left distal radius (wrist)	752804.3,2	Door panel	Possible
Fracture, comminuted, left distal ulna (wrist)	753204.3,2	Door panel	Possible
Laceration, minor (1 cm), left wrist	790602.1,2	Door panel	Possible

OCCUPANT KINEMATICS - 2006 Subaru Impreza

Driver Kinematics

The 19-year-old male driver was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. The seat was positioned to the rear most track position. The seat back angle was 19 degrees from vertical and the seat bottom angle was 14 degrees from horizontal. The driver's seat had an after market seat cover on at the time of the vehicle inspection. At impact with the Cobalt, the driver initiated a forward trajectory. He loaded the safety belt as he pitched forward. The case vehicle began a sharp counterclockwise rotation and the driver began pitching to the left. As the vehicle continued its



Figure 12. Possible contact to B pillar

rotation and tripped on its right side, the driver began moving towards the right. As the vehicle continued the rollover sequence, the driver pitched alternately from side to side while generally held in place by the safety belt until the vehicle came to rest on its top. At some point, the driver loaded the seat belt webbing, causing the left clavicle fracture. During the rollover, the driver's left arm likely contacted the left door panel, causing the wrist/forearm fractures. The driver's head possibly contacted the B pillar, causing the concussive injury and the scalp abrasions. Rescue personnel cut his seat belt off him. He was transported to a local hospital where he arrived with a Glasgow Coma Scale (GCS) score of 13. He was admitted and hospitalized for three days.

Attachment 1. Scene Diagram

