

On-Site Side Air Bag Investigation  
Dynamic Science, Inc. (DSI), Case Number DS08039  
2007 Honda Civic  
Washington  
November 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 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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<p>16. Abstract</p> <p>This two-vehicle crash occurred on November 1, 2008 in Auburn, Washington. The subject vehicle was a 2007 Honda Civic that was being driven by a restrained 18-year-old female. The other vehicle was a 1995 GMC Jimmy that was being driven by a restrained 37-year-old male and pulling a utility trailer. The crash site was a three-leg intersection that was controlled by a posted stop sign for traffic entering the north and southbound roadway from the west leg of the intersection. The crash occurred during daylight. The weather was raining and the roadway was wet.</p> <p>The Honda was traveling eastbound, and the GMC was traveling southbound. The driver of the Honda entered the intersection and initiated a left turn. The front end of the GMC impacted the left side of the Honda. At impact, the Honda driver's frontal air bag, left inflatable curtain (IC) air bag, and left seat-mounted side air bag deployed.</p> <p>The driver of the Honda sustained a cervical strain, minor lacerations to the face and hands, and a contusion to the left thigh. The driver of the GMC reported a non-incapacitating injury, and complained of pain to the abdomen, right wrist, and right knee. Both vehicles were towed from the scene due to damage and were later declared total losses by their respective insurance companies.</p>			
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**Dynamic Science, Inc.  
Crash Investigation  
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## Background

This on-site side air bag investigation focused on the air bag deployments in a 2007 Honda Civic LX (**Figure 1**) that was involved in a vehicle-to-vehicle crash. The crash occurred in November 2008 in the state of Washington. The subject vehicle was being driven by a 18-year-old female. The other vehicle was a 1995 GMC Jimmy sport utility vehicle that was being driven by a 37-year-old male. A 4-year-old male occupied the second row left seat of the GMC.



**Figure 1.** Subject vehicle, 2007 Honda Civic LX

The crash occurred within the T-intersection of a north/south roadway and an east/west roadway. The Honda was traveling east and initiated a left turn onto the north/south roadway. The GMC was traveling south in a through lane and entered the intersection as the Honda crossed the southbound lane. The front end of the GMC impacted the left side of the Honda.

The Honda was equipped with advanced dual-stage frontal air bags, seat-mounted side air bags, side impact inflatable curtain (IC) air bags, and safety belt pretensioners. At impact, the driver's frontal air bag, left seat-mounted side air bag, and left IC air bag deployed, and the driver's safety belt pretensioners actuated.

This on-site side air bag investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) during a review of National Automotive Sampling System (NASS) General Estimates System (GES) police reports. On December 12, 2008, DSI was forwarded the police report with instructions to obtain cooperation. Both vehicles were located at an insurance auction facility and DSI obtained permission to inspect both vehicles. Neither of the vehicles' Event Data Recorders (EDR) was supported by the Bosch Crash Data Retrieval (CDR) system. Permission to harvest the Honda's EDR was denied by the insurance company. The case was assigned on December 17, 2008, and the vehicle inspections were conducted on December 18, 2008.

## Summary

### Crash Site

The crash site was the three-leg T-intersection of a north/south roadway and an east/west roadway (**Figure 2**). The north/south roadway comprised two through lanes in each direction and a two-way left turn lane. The two-way left turn lane was separated from the through lanes by yellow dashes, solid stripes, and raised reflectors. The north/south travel lanes were separated by white dashed stripes and raised reflectors, and the outboard lanes were bordered by solid white fog lines. Outboard of the fog lines were raised concrete curbs and paved sidewalks. The sidewalk that bordered the west curb was 1.83 m (6.0 ft) in width. Abutting the west sidewalk was a raised dirt embankment and shrubbery that ascended to approximately 1.22 m (4.0 ft) above grade. The

embankment ascended to a paved parking lot belonging to an automobile dealership and sale vehicles were parked perpendicular to the roadway, beginning approximately 61.0 m (200 ft) north of the intersection and ending 4.0 m (13.1 ft) north of the apex of the northwest corner. Also on the raised embankment were street lamp posts, two small trees, and a large commercial sign that was positioned perpendicular to the roadway. The posted speed limit was for the north/south roadway was 64 km/h (40 mph).



**Figure 2.** Crash site, looking north

The east/west roadway comprised the west leg of the intersection and consisted of one lane for each direction of travel. The overall width of the roadway measured 10.15 m (33.3 ft) and while it was intended for two-way traffic, there were no center line or lane dividers. Bordering the north curb was a paved sidewalk followed by an ascending dirt embankment and shrubbery. The embankment stopped at a paved parking lot in which sale vehicles were parked perpendicular to the roadway. The posted speed limit was 40 km/h (25 mph). The intersection was controlled by a posted stop sign for eastbound traffic turning left or right onto the north/south roadway.

The roadway composition was asphalt, and it was wet at the time of the crash. The alignment for each roadway was straight and the profile was level. Light conditions were daylight, the weather was raining, and street lights were present but not illuminated. The crash occurred at 1247 hours.

### **Pre-Crash**

The Honda was traveling eastbound and approached the intersection. The driver stated in the interview that she stopped at the posted stop sign, looked but did not see any approaching traffic, and entered the intersection. Just prior to impact, she saw the GMC approaching. She removed her hands from the steering wheel and covered her head and face with her hands and arms, and raised knees so that her feet were not touching the foot controls or floor. The driver's statements in the interview revealed that she did not initiate any evasive maneuvers such as braking or steering.

The driver of the GMC was using the vehicle's manual safety belt and was traveling in the right southbound through lane. The second row passenger was a 4-year-old male who was reported by police to have been seated in a child safety seat. The vehicle was towing a small single axle cargo trailer. The driver of the GMC indicated to police that prior to the impact he quickly looked down at his power window controls in order to close a second row window.

### **Crash**

The front end of the GMC impacted the left side of the Honda. The Honda initiated a post-impact counterclockwise rotation, and was displaced forward and right to the southeast. The vehicle rotated approximately 160 degrees, and came to final rest with its rear tires at the east curb of the northbound outboard lane, and facing west. The vehicle's travel distance from impact to final rest was estimated to be 17.5 m (57.4 ft). The Honda's final rest position was determined based on-scene

photographs obtained from the automobile dealership. There was no scene evidence present at the time of the scene inspection.

Due to the GMC's towed trailing unit, the vehicle was out of scope of the WinSMASH program. For informational purposes, the estimated weight of the trailer was added to the curb weight of the GMC and the Standard algorithm of the WinSMASH program was used. For the Honda, the WinSMASH program computed a Total Delta-V of 40.0 km/h (24.9 mph); the longitudinal and lateral components were -25.0 km/h (-16.0 mph) and 30.6 km/h (19.0 mph), respectively. The Barrier Equivalent Speed (BES) for the Honda was 25.0 km/h (15.5 mph). For the GMC, the WinSMASH program computed a Total Delta-V of 29.0 km/h (18.0 mph); the longitudinal and lateral components were -27.3 km/h (-17.0 mph) and -9.9 km/h (-6.2 mph), respectively. The BES for the GMC was 36.5 km/h (22.7 mph). The WinSMASH results represent a borderline reconstruction.

After the impact, the GMC continued traveling south, and initiated a post-impact counterclockwise rotation. The towed trailer jack-knifed to the left. When the GMC came to final rest, the trailer was positioned between the west curb on the right and the GMC on the left, which resulted in minor intra-unit contact between the vehicle and the trailer. The vehicle came to final rest near the southwest corner, in the southbound lanes, and facing east. The vehicle's travel distance from impact to final rest was estimated to be 14.4 m (47.3 ft). Based on on-scene photographs, it was determined that the towed trailer remained connected to the vehicle during the entire crash sequence.

### **Post-Crash**

The driver of the Honda exited the vehicle through the front row right side door with assistance from on-scene emergency responders. She was later placed on a backboard and fitted with a cervical collar for ground transport to a local hospital. She was treated by emergency medical technicians from 1320 - 1340 hours during the transport to the medical center. She arrived at the emergency department at 1355 hours with a Glasgow Coma Score of 15, and was discharged at 1645 hours. Her injuries included a cervical strain, minor lacerations to the face and hands, and a contusion to the left thigh. The vehicle was towed due to damage and was later declared to be a total loss by the insurance company.

The driver of the GMC was reported by police to have sustained a non-incapacitating injury and complained of pain to the abdomen, right wrist and right knee. The 4-year-old male occupant seated in the second row was not injured. The GMC occupants' transport status and medical treatment were unknown. The vehicle was towed due to damage and was later declared to be a total loss by the insurance company.

### **Vehicle Data - 2007 Honda Civic LX**

The 2007 Honda Civic LX was identified by the Vehicle Identification Number (VIN): 1HGFA16557Lxxxxxx. The vehicle's date of manufacture was not known; the left front door was jammed shut and the VIN placard could not be viewed. The odometer reading was reported by the auction facility to be 7242 km (4500 mi); the electronic odometer could not be read due to the absence of power to the vehicle. The vehicle was equipped with a 1.8-liter, 4-cylinder engine, automatic transmission, and front wheel drive. The vehicle was equipped with power steering and

tilt and telescopic steering wheel functionality, 4-wheel anti-lock brakes, and daytime lights. The fuel system was configured for gasoline and included a single non-metallic fuel tank.

The vehicle manufacturer's recommended tire size was P205/55R16 and the recommended tire pressure was 221 kPa (32 psi). The vehicle was equipped with Goodyear Eagle RS-A P205/55R16 tires, which had a tire manufacturer's recommended maximum tire pressure of 303 kPa (44 psi). The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LR	165 kPa (24 psi)	6 mm (8/32 in)	No	None
LR	165 kPa (24 psi)	8 mm (10/32 in)	No	None
RR	172 kPa (25 psi)	7 mm (9/32 in)	No	None
RF	165 kPa (24 psi)	6 mm (8/32 in)	No	None

The Honda's interior was equipped with seating for five occupants. The front row seating consisted of fabric-covered bucket seats that were equipped with folding backs and adjustable head restraints. The second row seating consisted of a fabric-covered bench seat with separate backs and adjustable head restraints.

## Vehicle Damage

### Exterior Damage

The Honda sustained direct and induced damage to the left side plane. The direct damage began 19 cm (7.5 in) aft of the left front axle and extended 205 cm (80.7 in) rearward. The Field L began 27 cm (10.6 in) forward of the front left axle, extended 254 cm (100 in) rearward, and ended 40 cm (15.7 in) forward of the rear axle. Vertically, the direct damage began at the sill and extended to slightly above the beltline.

There was complete separation of the upper hinge of the front left door, and the impact damage overrode the sill. In accordance with NASS coding guidelines, the procedure for Crush

Average for Underride Damage was used to calculate the crush measurements. Two sets of crush measurements were obtained: one set at mid-door level, and one set at sill level. Measurement stands were set parallel to the vehicle and the reference line was positioned at one-half the vehicle width plus an increment to allow for protruding sheet metal (**Figure 3**). Later, the measurements were adjusted to accommodate the increment. Six crush measurements were taken at mid-door level as follows: C1 = 0 cm, C2 = 9 cm (3.5 in), C3 = 28 cm (11.0 in), C4 = 24 cm (9.5 in), C5 = 4 cm (1.6



**Figure 3.** Crush measurements, left side



in), C6 = 0. Maximum lateral crush was located at 151 cm (59.5 in) forward of the rear axle, between C3 and C4, and measured 31 cm (12.2 in).

The crush gauge was then lowered to sill height, and six crush measurements were taken as follows: C1 = 0 cm, C2 = 0 cm, C3 = 2 cm (0.8 in), C4 = 2 cm (0.8 in), C5 = 0 cm, C6 = 0. The resulting measurements yielded a greater than 13 cm (5.1 in) difference in crush at C3 and C4. Therefore, those crush measurements were averaged to obtain the final crush. The averaged crush measurements were as follows: C1 = 0 cm, C2 = 9 cm (3.5 in), C3 = 15 cm (5.9 in), C4 = 13 cm (5.1 in), C5 = 4 cm (1.6 in), C6 = 0. Maximum crush was not averaged, was located 151 cm (59.5 in) forward of the rear axle between C3 and C4, and measured 31 cm (12.2 in). The Collision Deformation Classification (CDC) for the Honda was 10LYAW2.

The height of the maximum door crush was 67 cm (26.4 in), the sill height was 34 cm (13.4 in), and the Door Sill Differential (DSD) was 28 cm (11.0 in).

During the crash, the front left exterior door panel and side impact bar were displaced from the vehicle. The side impact bar was found with the vehicle during the inspection; the exterior door panel was not found. The side impact bar measured 100 cm (39.4 in) in length and 4 cm (1.2 in) in diameter. The bar was deformed near its longitudinal midpoint and was bent inboard at an angle of 55 degrees. The bar was not fractured and was displaced from the vehicle in one piece.

### **Interior Damage**

The Honda sustained moderate interior damage as a result of passenger compartment intrusions and occupant contact. The left side opera window and front row left window glazing disintegrated and the window frame was deformed. The deformation revealed a gap between the window frame and left roof side rail that measured 15 cm (5.9 in) at its maximum protrusion. The windshield sustained stress cracks and remained in place. The left side doors were jammed shut. The left interior door panel intruded into the left instrument panel and the contact fractured both components. The occupant contacted the intruding door panel and deposited a 2 cm (0.8 in) scuff to the armrest. The left B-pillar intruded into the driver's seat cushion and resulted in deformation of the cushion.

### **Manual Restraints**

The Honda was equipped with 3-point manual lap and shoulder belts for the front row outboard seating positions. The belts were configured with sliding latch plates, adjustable D-rings, retractor pretensioners and buckle pretensioners.

The driver's safety belt anchorage adjustment was in the full down position. The safety belt was equipped with an Emergency Locking Retractor (ELR). The latch plate was lightly scratched indicating historical usage. The belt and buckle exhibited no signs of occupant loading. The belt retractor pretensioner had actuated during the crash and the retractor was locked with the belt webbing slack and in the used position. The buckle pretensioner also retracted and measurement of the buckle stalk revealed a retraction distance of 4 cm (1.2 in). Based on the webbing locked in the used position and occupant kinematics, the front row left safety belt was determined to have been used by the driver during the crash.

The front row passenger's safety belt was equipped with an adjustable D-ring anchorage, which was in the mid position. The sliding latch plate exhibited light scratches indicating historical usage. The belt had an ELR/Automatic Locking Retractor (ALR).

The second row seats were equipped with 3-point manual lap and shoulder belts. The belt restraints were integrated and they retracted through ports in the seat backs. The belts were configured with switchable ELR/ALR. The safety belt latch plates were lightly scratched indicating historical usage.

### Supplemental Restraint Systems

The Honda's Supplemental Restraint System (SRS) included an EDR, driver and passenger frontal air bags, side impact IC air bags, seat-mounted side air bags, front and side impact sensors, and retractor and buckle safety belt pretensioners. The frontal air bags were housed in the steering wheel hub and the middle instrument panel, respectively. The IC air bags were housed in the left and right roof side rails, and the seat-mounted side air bags were housed in the front row seat-backs.



**Figure 4.** Deployed air bags, subject vehicle

The vehicle's frontal air bags were advanced dual-stage Certified Advanced 208-Compliant (CAC).

The air bags were certified by the manufacturer to be compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

At impact, the driver's frontal air bag, left seat-mounted side air bag, and left IC air bag deployed (**Figure 4**), and the safety belt retractor and buckle pretensioners actuated. The driver's frontal air bag deployed through one upper and two lower cover flaps on the steering wheel hub. The cover flaps opened at their tear points and were not damaged. The module cover had moved rearward of the steering column approximately 2 cm (0.8 in) at its upper aspect. The resulting gap between the module and steering column did not constitute damage or malfunction.

The air bag was circular in shape and measured 56 cm (22.0 in) in diameter. There was a circular stitching pattern on the front panel that measured 16 cm (6.3 in) in diameter. The air bag was configured with two vent ports that measured 5 cm (2.0 in) in diameter, which were located on the bag's back at the 11 and 1 o'clock positions, and two internal tethers.

Evidence of slight damage was present in the upper and lower right and lower left quadrants on the front panel of the air bag. Vinyl striations from the cover flaps were noted in the upper and lower right quadrants. Four small yellow-colored spots measuring 1 - 2 mm (0.4 - 0.8 in) in diameter were located that lower right quadrant and were consistent in appearance with thermal damage. Two additional small thermal marks were present in the lower left quadrant. The air bag did not show any occupant contact evidence.

The driver's left seat-mounted side air bag deployed during the crash. The air bag deployed from a module in the outboard aspect of the seat back. The air bag was generally oval in shape and measured 52 cm (20.5 in) in length, 35 cm (13.8 in) in width at the upper aspect and 25 cm (9.8 in) in width at the lower aspect. A 5 cm (2.0 in) vent port was located at the leading edge. The air bag revealed no damage or evidence of occupant contact. The air bag covered a section of the door panel that began at the upper edge of the door panel and extended down to the seat cushion, and included the door's rearward upper and lower quadrants.

The vehicle's left IC air bag deployed from the roof side rail. The air bag exhibited 22 longitudinal folds, and measured 180 cm (70.9 in) in width and 42 cm (16.5 in) in width. It was configured with 5 vent ports that measured 2 cm (0.8 in) in diameter. The air bag extended from the A-pillar to the C-pillar, and from the roof side rail to approximately 10 cm (3.9 in) below the top of the front row door panel. There was no damage or suspected occupant contacts observed on the inboard panel. There were a few light-colored marks on the outboard panel that were striations from the roof cladding. The air bag exhibited several green and yellow markings that originated during the manufacturing of the air bag.

#### Vehicle Data - 1995 GMC Jimmy

The 1995 GMC Jimmy was identified by the Vehicle Identification Number (VIN): 1GKCS13W4S2xxxxxx, and the vehicle's date of manufacture was December 1994. The odometer reading was 435,116 km (27,0376 mi). The vehicle was equipped with a 4.3-liter, 6-cylinder engine, automatic transmission, and rear wheel drive. The fuel system was configured for gasoline and included a single metallic fuel tank.

The vehicle manufacturer's recommended tire size was P235/70R15 and the manufacturer's recommended tire pressure was 221 kPa (32 psi). The vehicle's front wheels were equipped with Goodyear Weatherhandler LS P205/75R15 tires, which had a tire manufacturer's recommended maximum tire pressure of 303 kPa (44 psi). The rear wheels were equipped with BFGoodrich Revelation P205/75R15 tires, which had a tire manufacturer's recommended maximum tire pressure of 241 kPa (35 psi). The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LR	Tire flat	6 mm (7/32 in)	Yes	De-beaded
LR	193 kPa (28 psi)	2 mm (3/32 in)	No	None
RR	159 kPa (23 psi)	3 mm (4/32 in)	No	None
RF	179 kPa (26 psi)	5 mm (6/32 in)	No	None

## Vehicle Damage - 1995 GMC Jimmy

### Exterior Damage

The GMC sustained direct and induced damage to the front end from the vehicle-to-vehicle impact, and left side damage from intra-unit contact. The direct damage to the front end began at the vehicle's front left bumper corner and extended 95 cm (37.4 in) to the right. The vertical extent of direct damage began at the bumper and extended upward to the hood. The Field L began at the front left bumper corner and extended 134 cm (52.8 in) to the front right bumper corner (**Figure 5**).



**Figure 5.** Crush measurements, front end

Six crush measurements were taken at bumper level as follows: C1 = 60 cm (23.6 in), C2 = 40 cm (15.8 in), C3 = 33 cm (13.0 in), C4 = 26 cm (10.2 in), C5 = 10 cm (3.9 in), C6 = 1 cm (0.4 in).

Maximum longitudinal crush was located at C1 and measured 60 cm (23.6 in). The CDC for the GMC was 01FDEW3.

The GMC sustained intra-unit damage when the towed trailer jack knifed and contacted the vehicle's left rear quarter panel. The direct damage began at the rear left bumper corner and extended forward to the rearward aspect of the rear wheel well. The contact fractured and displaced the side molding; however, there was no residual crush to the sheet metal. The CDC for the intra unit impact was 00LBEW1.

## Occupant Demographics - 2007 Honda Civic

<b>Driver</b>	
Age/Sex:	18/Female
Seated Position:	Front left
Height:	163 cm (64 in)
Weight:	48 kg (105 lb)
Seat Type:	Bucket with folding back
Seat Track Position:	Mid-track
Manual Restraint Usage:	Lap and shoulder belt
Usage Source:	Vehicle inspection
Body Posture:	Turned slightly to right
Hand Position:	Covering head and face
Foot Position:	Raised off of floor
Air Bags:	Frontal air bag, seat-mounted side air bag, side curtain air bag, deployed
Alcohol/Drug Involvement:	None
Medical Treatment:	Transported, treated and released

## Occupant Kinematics - 2007 Honda Civic

### Driver Kinematics

The 18-year-old female driver was seated in normal posture and was restrained by the vehicle's 3-point manual lap and shoulder safety belt. She was actively steering the vehicle with both hands and her right foot was on the accelerator. The driver stopped for a posted stop sign, then slowly accelerated to a driver-estimated speed of 16 - 24 km/h (10 - 15 mph) while initiating a left turn. The driver stated that she did not see the other vehicle until just prior to the moment of impact. She removed her hands from the steering wheel and covered her head and face with her hands and arms, and raised knees so that her feet were not touching the foot controls or floor. The driver's statements in the interview revealed that she did not initiate any evasive maneuvers such as braking or steering.

At impact, the left door intruded into the driver compartment contacting the left instrument panel and the driver's seat cushion, and the left B-pillar intruded and deformed the driver's seat-back. The driver's frontal air bag, left seat-mounted side air bag, and left IC air bag deployed; the safety belt's retractor and buckle pretensioners actuated. The front row left side window glazing disintegrated.

The driver was displaced to the left and slightly forward, in response to the vehicle's 10 o'clock direction of force. She sustained a cervical strain due to the impact forces. She probably loaded the

safety belt; however, no evidence of occupant loading was observed on the belt webbing or hardware. The driver's left thigh contacted the left side door hardware located in the forward upper quadrant resulting in a contusion to the left thigh. The armrest revealed a 2 cm (0.8 in) scuff that was located 30 cm (11.8 in) below the top and 30 cm (11.8 in) forward of the trailing edge of the door panel. She sustained bilateral minor lacerations to the hands and face due to contact with flying glass. The driver stated in the interview that her head probably contacted the left IC air bag and she then lost consciousness for approximately 30 seconds. However, there was no physical evidence of contact between the driver's head and any interior component.

The vehicle initiated a post-impact counterclockwise rotation and was displaced to the right. The driver was held in place in her seat by the vehicle's lap and shoulder belt. The vehicle rotated counterclockwise 160 degrees and came to final rest facing west at the east curb of the northbound travel lane.

### Occupant Injuries - 2007 Honda Civic

#### Driver

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Cervical strain	640278.1,6	Impact forces	Probable
Lacerations, minor, face, multiple regions	290602.1,9	Flying glass	Certain
Lacerations, minor, bilateral hands	790602.1,3	Flying glass	Certain
Contusion, left thigh	890402.1,2	Left door panel/hardware; forward upper quadrant	Certain
Driver-reported loss of consciousness	Not codeable <sup>1</sup>		

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<sup>1</sup> The level of consciousness and its duration must be observed by emergency or medical personnel

Attachment 1. Scene Diagram

