

On-Site Side Air Bag Investigation  
Dynamic Science, Inc. (DSI), Case Number DS08040  
2003 Honda Accord  
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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**Case Number: DS08040**

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## Background

This on-site side air bag investigation focused on the dynamics and air bag deployments of a 2003 Honda Accord (**Figure 1**) that was involved in a vehicle-to-vehicle crash. The crash occurred in November 2008 in the state of Washington. The Honda was being driven by a 39-year-old female, the first other vehicle was a 2004 Hyundai Elantra that was being driven by a 67-year-old female, and the second other vehicle was a 1995 Toyota Tacoma that was legally parked with no driver present. The crash site was a four-leg intersection consisting of a north/south roadway and an east/west roadway.



**Figure 1.** Subject vehicle, 2003 Honda Accord

The Honda was traveling east, the Hyundai was traveling south, and the Toyota was parked parallel to the north curb and facing west. The Honda and the Hyundai entered the intersection at the same time, and the Honda crossed the path of the Hyundai. The front end of the Hyundai impacted the left side of the Honda. The Honda was equipped with advanced dual stage frontal air bags, seat-mounted side air bags, side curtain air bags, and safety belt pretensioners. At impact, the left seat-mounted side air bag and the left side curtain air bag deployed, and the driver's safety belt pretensioner actuated. The Honda then traveled to the northeast corner of the intersection and the vehicles's front right bumper contacted the front left corner of the Toyota. Following the impact with the Toyota, the Honda rolled forward and its right front tire impacted a curb.

This on-site side air bag investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) during a review of General Estimates System (GES) police reports. On December 12, 2008, DSI was forwarded the police report with instructions to obtain cooperation. The vehicle was located at an insurance auction facility and on December 16, 2008, DSI obtained permission to inspect the subject vehicle. Permission to remove the vehicle's event data recorder (EDR) was denied by the insurance company. The reason given was potential loss of value due to damage caused during the removal. The case was assigned on December 16, 2008 and the inspection was completed on December 17, 2008.

## Summary

### Crash Site

The crash site was a four-leg intersection consisting of an east/west roadway and a north/south roadway (**Figure 2**). The flow for each roadway was undivided for two way traffic. The roadway composition was concrete and it was dry at the time of the crash. The east/west roadway comprised one lane in each direction and curb parking was permitted outboard of the travel lanes. The travel lanes were separated by yellow dash stripes. The roadway width measured 11.7 m (38.5 ft) in its entirety. The travel lanes were not delineated from the parking lanes. Adjacent to the parking lanes

were 15 cm (5.9 in) concrete curbs and paved sidewalks. Parking was not permitted within 9.1 m (30.0 ft) of the intersection. A bus stop near the north curb began at the northwest corner of the intersection and extended west for approximately 30 m (100 ft), and parking was prohibited within that area. Trees and utility poles were spaced intermittently along the curbs and sidewalks. The posted speed limit was 48 km/h (30 mph).



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

The alignment for the east/west roadway was straight. The pre-crash roadway profile for the Honda was variable. The eastbound approach to the intersection was an uphill grade of positive 5.0 percent grade at 46 m (150 ft), positive 5.5 percent at 30 m (100 ft), and positive 5.6 percent at 15 m (50 ft). Within the intersection, the profile was level; the grade at the area of impact measured positive 0.9 percent in the eastbound lane. East of the intersection, the grade increased to a positive 4.5 percent. The area of the second impact was located approximately 9.1 m (30.0 ft) west of the intersection, where the eastbound profile was a positive 4.5 percent grade.

The north/south roadway comprised one lane for each direction of travel and a parking lane outboard of the southbound lane. The alignment for the north/south roadway was straight. The pre-crash roadway profile for the Hyundai was slightly negative to level. From 30 m (100 ft) north of the intersection to the area of impact the grade was level. The lanes were not striped; the overall roadway width measured 7.1 m (23.2 ft). Parking was not permitted within 9.1 m (30.0 ft) of the intersection. The roadway was bordered by 15 cm (5.9 in) curbs, grass medians and paved sidewalks. Trees and utility poles were spaced intermittently on the medians. The posted speed limit was 40 km/h (25 mph).

The intersection was controlled by posted stop signs for north and southbound traffic. The stop sign located at the northwest corner of the intersection was 5.2 m (17.0 ft) to the north and 1.0 m (3.0 ft) to the west of the curb apex. The bottom of the sign was 2.2 m (9.0 ft) above grade. According to local parking restrictions, there should have been no parked vehicles within 9.1 m (30.0 ft) of the stop sign. The sign's graphics comprised a reflective background and lettering. Neither the police report nor the Hyundai driver's statements indicated that there were any visual obstructions present that blocked the driver's view of the stop sign. The driver of the Hyundai indicated to police that she was not sure she stopped at the stop sign before proceeding into the intersection.

The specific time of the crash was not reported by police. The patrol officer was dispatched at 1736 hours. Conditions were reported by police to be dark with street lights on, and the weather was reported to be clear to partly cloudy. According to the nearest weather reporting station, the time of sunset for the crash date was 1632 hours and the weather was clear. The driver of the Honda stated in the interview that conditions were dusk to dark. It was therefore determined that conditions were dark with streetlights illuminated.

## Pre-Crash

The Honda was traveling eastbound and the Hyundai was traveling southbound as each vehicle entered the intersection (**Figure 3**). While traversing the intersection, the Honda crossed the path of the Hyundai. The driver of the Honda continued to steer the vehicle forward with her foot on the accelerator, and the vehicle was tracking in its original travel lane.

The Toyota was parked approximately 9.1 m (30.0 ft) east of the intersection, parallel to the north curb, and facing west. The driver was not present. For the west-facing parking lane, the profile was measured a negative 4.5 percent grade.



**Figure 3.** Eastbound approach, subject vehicle

## Crash

The front end of the Hyundai impacted the left side of the Honda (Event 1). The contact was to the left B-pillar and the second row door. The Honda initiated a post-impact, counterclockwise rotation, departed the eastbound lane and entered the westbound lane. The vehicle's post-impact trajectory was in a northeast direction and the vehicle rotated approximately 150 degrees and traveled approximately 16.0 m (52.5 ft). At that point the Honda was heading generally westbound, and the vehicles's front right bumper contacted the front left corner of the Toyota (Event 2). The second impact was a swiping type contact to the bumper corner, and resulted in a low Delta-V event. The Honda was then heading northwest in the westbound lane, which had a downhill grade of negative 4.5 percent. The vehicle rolled out in a generally straight path for approximately 8.0 m (26.3 ft) and the right front tire and rim contacted a concrete curb (Event 3). The aluminum rim and tire sustained gouges and scratches from contact with the concrete curb. The Honda then came to final rest at the northeast corner of the intersection and facing northwest. The vehicle's final rest position was based on the police report and driver interview.

For the first event, the Missing Vehicle algorithm of the WinSMASH program computed a Total Delta-V of 9 km/h (5.6 mph) for the Honda; the longitudinal and lateral components were -8 km/h (-5 mph) and 4 km/h (2.5 mph), respectively. Based on the Honda's crush profile and the vehicle's post impact trajectory, the results appear reasonable.

The Hyundai initiated a post impact, counterclockwise rotation, and was displaced to its left. It rotated an estimated 90 degrees, and traveled an estimated 9.0 m (29.5 ft). The vehicle came to final rest facing east, near the curb of the southeast corner. The vehicle's final rest position was based on the police report and scene diagram.

For the first event, the Missing Vehicle algorithm of the WinSMASH program computed a Total Delta-V of 11 km/h (6.8 mph) for the Hyundai; the longitudinal and lateral components were -6 km/h (-3.7 mph) and -10 km/h (-6.2 mph), respectively.

Based on the police report, the Toyota remained stationary during the crash. The vehicle was reported by police as not towed and was presumably driven from the scene.

### Post-Crash

The driver of the Honda exited the vehicle unassisted through the front row left side door and the driver of the other vehicle did likewise. The drivers each refused treatment at the scene. The driver of the Honda sustained minor injuries including cervical and thoracic strains and a complaint of headaches. She sought treatment later from a chiropractor and was treated for five months after the crash. She missed one day from work due to her injuries.

The driver of the Hyundai was reported by police to have been uninjured. The Hyundai and the Toyota were driven from the scene. The Honda was towed from the scene due to damage and was later declared a total loss by the insurance company.

### Vehicle Data - 2003 Honda Accord

The 2003 Honda Accord was identified by the Vehicle Identification Number (VIN): 1HGCM668X3Axxxxxx and the vehicle's date of manufacture was March 2003. The electronic odometer reading was 140,455 km (87,277 mi). The vehicle was equipped with a 3.0-liter, 6-cylinder engine, automatic transmission, front wheel drive, power steering, a tilt and telescopic steering wheel, 4-wheel anti-lock brakes, electronic throttle control, and daytime lights. The fuel system was configured for gasoline and included a single nonmetallic fuel tank.

The vehicle manufacturer recommended P205/60R16 tires for the front and the rear, and a cold tire pressure of 221 kPa (32 psi) for the front and 207 kPa (30 psi) for the rear. The vehicle was equipped with Michelin Energy MXV4 tires, size P205/60R16, 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
LF	152 kPa (22 psi)	5 mm (6/32 in)	No	None
LR	172 kPa (25 psi)	6 mm (8/32 in)	No	None
RR	172 kPa (25 psi)	6 mm (8/32 in)	No	None
RF	Tire flat	6 mm (7/32 in)	No	Tire de-beaded, sidewall gouged and abraded

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



## Vehicle Damage

### Exterior Damage

The Honda sustained direct damage to the left side, the front end, the right side, and the right front tire and rim. The first impact resulted in direct and induced damage to the Honda's left side plane. The direct damage began at 135 cm (53.2 in) forward of the rear axle, extended rearward 173 cm (68.1 in), and ended 38 cm (15.0 in) aft of the rear axle. The Field L began at 155 cm (61.0 in) forward of the rear axle, extended rearward 202 cm (79.5 in), and ended 47 cm (18.5 in) aft of the rear axle.



**Figure 4.** Crush measurement left side

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 4**). Six crush measurements were taken at mid-door level as follows: C1 = 0 cm, C2 = 4 cm (1.6 in), C3 = 12 cm (4.7 in), C4 = 12 cm (4.7 in), C5 = 4 cm (1.6 in), C6 = 0. Maximum lateral crush was located at 50 cm (19.7 in) forward of the rear axle, between C3 and C4, and measured 14 cm (5.5 in).

The height of the maximum door crush was located on the second row door and measured 61 cm (24.0 in); the sill height was 28 cm (11.0 in), and the Door Sill Differential (DSD) was 10 cm (3.9 in). The hinges and sill were not damaged in the crash. The left rear door was jammed shut and the window frame was deformed outboard of the vehicle revealing a 2 cm (0.8 in) gap. The Collision Deformation Classification (CDC) for the Honda's first impact was 11LZEW2.

The Honda sustained a second vehicle-to-vehicle impact that involved a parked 1995 Toyota Tacoma. Direct damage to the Honda was located on the front right bumper fascia. The direct damage began at the front right bumper corner and extended 13 cm (5.1 in) to the left and consisted of surface scratches. The damage extended down the right side for 39 cm (15.4 in) from the bumper corner to the end of the component and terminated at the forward aspect of the right front wheel well. During the impact, the right bumper fascia was partially displaced 1-2 cm (0.4-0.8 in) forward of its original position. Due to the forward movement of the component, there was no measurable crush. The extent zone for the CDC was determined by the damage down the vehicle's right side. The CDC for the Honda's second impact was 12FRLS3.

The Honda sustained a third impact when the vehicle's right front tire and rim contacted a raised 15 cm (5.9 in) concrete curb. The perimeter of the rim was gouged and the tire's sidewall was abraded and gouged. The gouge to the sidewall was located 2 cm (0.8 in) from the rim and measured 3 cm (1.2 in) in length. The tire was flattened and de-beaded. The CDC for the Honda's third impact was 12RFWS2.

## **Interior Damage**

The Honda sustained minor interior damage as a result of passenger compartment intrusion and occupant contacts during the crash. The windshield sustained stress cracking in the lower right corner and remained in place. The left rear door was jammed shut. The remainder of the doors remained closed and operational. The rear lower quadrant of the second row left door panel and the armrest intruded laterally into the second row.

## **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-ring anchorages, and retractor pretensioners.

The driver's safety belt anchorage adjustment was in the full down position. The latch plate was lightly scratched indicating historical usage. The safety belt was equipped with an Emergency Locking Retractor (ELR). The belt webbing, D-ring and buckle showed no signs of occupant loading. The belt retractor pretensioner had actuated during the crash and the retractor was locked with the safety belt in the used position. Based on the post-crash status of the safety belt and the driver's kinematics, the safety belt was determined to have been used to restrain the driver during the crash.

The front row passenger safety belt was equipped with a switchable ELR/Automatic Locking Retractor (ALR). The latch plate was scratched indicating historical usage.

The second row seats were equipped with 3-point manual lap and shoulder belts that were equipped with integrated ELR/ALR retractors in the seat backs. The safety belt latch plates were lightly scratched indicating historical usage. The left and right safety belt webbing had been cut and the shoulder portion of the belts had retracted into the seat back. The lap portion of the belts were attached to lower anchorages and they emerged through the seat bight; the loose ends remained on the seat cushion. The sliding latch plates had been displaced from the belts and were found on the seat cushion. The reason for the belts being cut was unknown and the driver could not provide any additional information during the interview. The visible sections of belt webbing exhibited no evidence of occupant loading or other damage.

## **Supplemental Restraint Systems**

The Honda's Supplemental Restraint System (SRS) included an air bag control module (ACM), driver and passenger frontal air bags, side impact inflatable curtain (IC) air bags, seat-mounted side air bags, front and side impact sensors, and safety belt pretensioners for the front row seats.

The frontal air bags were an advanced dual-stage design but were not Certified Advanced 208-Compliant (CAC). The driver's air bag was located in the steering wheel hub and the passenger air bag was located in the top instrument panel. The crash resulted in insufficient changes in velocity to deploy the frontal air bags.

The front row was equipped with seat-mounted side air bags. The driver's seat mounted-side air bag deployed during the first impact (**Figure 5**) through a seam at outboard side of the left seat back. The air bag was hexagonal in shape, measured 34 cm (13.4 in) at its maximum height, and 28 cm (11.0 in) at its maximum width. It was configured with one vent port and had no tethers.



**Figure 5.** Deployed seat-mounted side air bag

In its deflated state, the air bag's area of coverage began at the bottom of the side glass and extended downward to approximately 10 cm (3.9 in) below the armrest. The seat track position was found adjusted between the mid- to full-forward setting and in that position the air bag's rearward aspect began at the B-pillar and extended forward into the door panel's upper rear quadrant. The air bag was not wide enough to extend to the door's longitudinal center. The forwardmost 12 cm (5.0 in) of the armrest was not covered by the air bag.

The seat-mounted side air bag was not damaged and no occupant contacts were identified. A small area of vinyl striations were located on both the inboard and outboard panels and otherwise the seat-mounted side air bag was unremarkable. The driver stated in the interview she did not contact any left side components or air bags during the crash.



**Figure 6.** Deployed side impact inflatable curtain air bag

The vehicle was equipped with side impact IC air bags and the left side IC air bag deployed during the first impact (**Figure 6**). The left side IC air bag deployed from the roof side rail above the front and second row doors.

The IC air bag had 22 longitudinal folds and measured 170 cm (66.9 in) in width and 43 cm (16.9 in) in length in its deflated state. It was configured with three vent ports that measured 2 cm (0.8 in) in diameter and fourteen smaller vent ports measuring 1 cm (0.4 in) in diameter that were located near a stitching pattern that ran the length and width of the air bag. One external tether attached the air bag to the vehicle at 16 cm (6.3 in) from the top of the A-pillar. The air bag covered approximately 70 percent of the front row window glazing and 100 percent of the second row glazing. Vertically, the air bag extended from the roof rail to 12 cm (3.9 in) below the bottom of the front row side glass and it provided coverage for the driver from the rear upper door panel, the B-pillar, and the safety belt upper anchorage assembly. No damage or occupant contacts were observed on either side of the air bag.

### Vehicle Data - 2004 Hyundai Elantra

The 2004 Hyundai Elantra was identified by VIN: KMHDN46D74Uxxxxxx. The Hyundai was a 4-door sedan that was equipped with a 4-cylinder, 2.0-liter engine and front wheel drive. The police report indicated the vehicle sustained damage distributed across the front end of the vehicle and the vehicle was driven from the scene.

### Vehicle Data - 1995 Toyota Tacoma

The 1995 Toyota Tacoma was identified by VIN: 4TAUN41BXSZxxxxxx. The Toyota was a 2-door pickup truck with a regular size cab. Standard equipment included a 4-cylinder, 2.4-liter engine, and 2-wheel, rear-wheel drive transmission. The police report indicated the vehicle sustained damage to the front left corner of the vehicle. The driver of the vehicle was not present at the time of the crash and police did not order the vehicle towed.

### Occupant Demographics - 2003 Honda Accord

	<b>Driver</b>
Age/Sex:	39/Female
Seated Position:	Front left
Height:	164 cm (65 in)
Weight:	85 kg (187 lb)
Seat Type:	Bucket
Seat Track Position:	Between forward- and mid-track
Manual Restraint Usage:	Lap and shoulder belt
Usage Source:	Vehicle inspection
Body Posture:	Upright
Hand Position:	Both hands on steering wheel
Foot Position:	Right foot on accelerator, left foot on floor
Air Bags:	Seat-mounted side air bag, side curtain air bag, deployed; frontal air bag not deployed
Alcohol/Drug Involvement:	None
Medical Treatment:	Sought treatment later from private physician

## **Occupant Kinematics - 2003 Honda Accord**

### **Driver Kinematics**

The 39-year-old female driver was seated in an upright posture and was restrained by the vehicle's 3-point manual lap and shoulder belt. The shoulder portion of the safety belt was snug across her left shoulder and collarbone and the lap portion was snug and low across her hips. The driver related during the interview that she was actively steering the vehicle with her hands at the 10 and 2 o'clock positions on the steering wheel and her right foot was on the accelerator. She also related that she was wearing prescription eyeglasses at the time of the crash. The vehicle was traveling at a driver-estimated speed of between 32 - 64 km/h (20 - 40 mph) on a straight road with a positive grade of 5.5 percent. The driver entered the intersection, which was level at the crest of the hill, and the front end of the Hyundai impacted the left side of the Honda slightly aft of the Honda's longitudinal center of gravity.

At impact, the left seat-mounted side air bag and the left IC air bag deployed, and the driver's safety belt pretensioner actuated. The driver was displaced left and forward in response to the Honda's 11 o'clock direction of force and loaded the vehicle's safety belt. She sustained cervical and thoracic muscle strains due to impact forces.

Based on the direction of force and air bag deployments, it is probable the driver contacted the air bags during the crash sequence. However, no physical evidence of occupant contacts were identified, the driver had no recollection of air bag contact, and no injuries could be attributed to such contact. There also was no physical evidence of occupant contact to the steering wheel.

After the impact, the Honda initiated a counterclockwise rotation and traveled slightly uphill as the roadway's positive grade increased. During the vehicle's post-impact rotation, the driver was displaced to the right and remained held in place by the lap and shoulder belt.

After traveling a short distance, the Honda's front right bumper contacted the parked Toyota in what was a low Delta-V event. A Delta-V value was not computed due to the swiping type impact configuration; however, the damage was minor and based on the vehicle's crush damage and post-impact trajectory it was reasonable to determine the Delta-V for the event was  $< 16$  km/h (10 mph). The driver's hands were still on the steering wheel and her feet were on the floor. The impact had minimal effect on the driver's kinematics. The Honda was then heading northwest in the westbound lane, which had a downhill grade of negative 4.5 percent. The vehicle rolled out in a generally straight path and the right front tire and rim contacted a concrete curb. That also was a low Delta-V event and had minimal effect on the driver's movement or action. The vehicle came to final rest near the curb.

## **Occupant Injuries - 2007 Honda Civic**

### **Driver Injuries**

The police did not report any injuries. The driver stated in the interview that she refused treatment at the scene and was not transported. She later sought treatment from a chiropractor for her soft

tissue injuries. The driver's specific injuries were as follows:

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Cervical strain	640278.1,6	Impact forces	Probable
Thoracic strain	640478.1,7	Impact forces	Probable

Attachment 1. Scene Diagram

