

# INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER  
School of Public and Environmental Affairs

## ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN11040  
LOCATION - OHIO  
VEHICLE - 2006 Honda CR-V EX  
CRASH DATE - October, 2011

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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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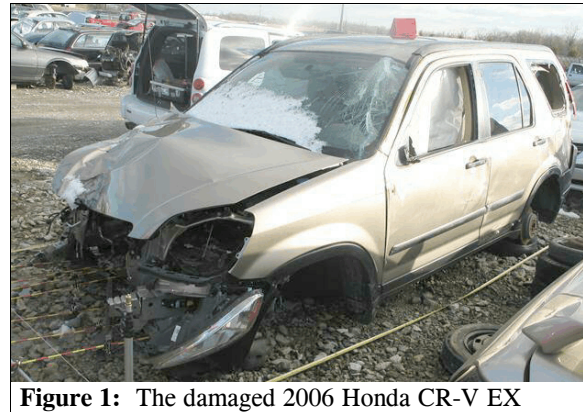
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**ON-SITE ROLLOVER INVESTIGATION**  
CASE NUMBER - IN11040  
LOCATION - OHIO  
VEHICLE - 2006 Honda CR-V EX  
CRASH DATE - October 2011

**BACKGROUND**

This on-site investigation focused on the rollover of a 2006 Honda CR-V EX (**Figure 1**) and the sources of the driver's injuries. This crash was initiated by the National Highway Traffic Safety Administration (NHTSA) on November 22, 2011 through the sampling activities of the National Automotive Sampling System (NASS)-General Estimates System (GES). This investigation was assigned on November 28, 2011. The crash involved the Honda and a 1990 Geo Prizm. The crash occurred in October, 2011, at 0715 hours, in Ohio and was investigated by the highway patrol. The Honda and crash scene were inspected on November 29, 2011. The driver interview was completed on January 11, 2012.



**Figure 1:** The damaged 2006 Honda CR-V EX

This crash occurred within the 4-leg intersection of a U.S. highway and a rural roadway when the driver of the eastbound Geo initiated a left turn and was impacted by the westbound Honda. The Honda rolled over, left side leading, four quarter turns following the impact. The Honda was a 4-door, sport utility vehicle equipped with dual stage frontal air bags, front seat-mounted side impact air bags, and roof side rail-mounted rollover/side impact Inflatable Curtain (IC) air bags. A restrained 70-year-old female driver occupied the vehicle. The driver's frontal air bag deployed during the impact with the Geo. Both of the Honda's IC air bags deployed during the rollover. The driver sustained minor injuries and was transported by ground ambulance to a hospital where she was treated in the emergency room and released. The Geo was occupied by a restrained 17-year-old male driver and restrained 13-year-old female front right passenger. The driver sustained "B" (non-incapacitating) injuries and the passenger sustained "C" (possible) injuries. The driver and passenger were transported by ground ambulance to a hospital. Both vehicles were towed from the crash scene due to damage.

**CRASH SUMMARY**

**Crash Site:** This crash occurred at dawn within the 4-leg intersection of a 2-lane U.S. highway and a 2-lane rural roadway. The weather conditions were cloudy according to the police crash report. The Honda and Geo were traveling on the U.S. highway, which traversed in an east/west direction. The westbound and eastbound lanes were 2.8 m (9.1 ft) and 3 m (9.8 ft) wide,

respectively on the east leg of the intersection. The westbound and eastbound lanes were 3.5 m (11.5 ft) and 3.8 m (12.5 ft) wide, respectively on the west leg of the intersection. The roadway was bordered by bituminous shoulders that were approximately 1 m (3.3 ft) wide. The roadway pavement markings consisted of solid white edge lines and a broken white center line. The roadway surface was dry bituminous and the grade was level. The speed limit was 89 km/h (55 mph). The Scene Diagram is included on page 9 of this report.

**Pre-Crash:** The Honda was traveling west approaching the intersection (**Figure 2**) and was behind a tractor semi-trailer. The driver of the Honda intended to continue traveling straight through the intersection. The Geo was traveling east and the driver intended to turn left at the intersection and travel north on the rural roadway. The driver of the Geo initiated the left turn immediately after the tractor semi-trailer traveled through the intersection. The driver of the Honda stated during the SCI interview that she had no time to take any avoidance actions.

**Crash:** The front plane of the Honda (**Figure 3**) impacted the right plane of the Geo (event 1). The force direction on the Honda was within the 11 o'clock sector and the impact triggered deployment of the driver's frontal air bag. The missing Vehicle Algorithm of the WinSMASH program calculated the total Delta V for the Honda as 35 km/h (21.7 mph). The longitudinal and lateral velocity changes were -30 km/h (-18.6 mph) and 18 km/h (11.2 mph), respectively. Following the impact, the Honda rotated clockwise approximately 110 degrees and rolled over (event 2), left side leading, four quarter turns. The rollover event triggered deployment of both IC air bags. The vehicle departed the right side of the roadway during the rollover (**Figure 4**) and came to final rest on its wheels heading north.

The Geo came to final rest in the north leg of the intersection heading southeast.

**Post-Crash:** The police were notified of the crash at 0719 hours and arrived at the crash scene at 0751 hours. The driver of the Honda exited the vehicle with the assistance of emergency



Figure 2: Westbound approach of the Honda; the Geo was heading east approaching the Honda



Figure 3: Damage to the front plane of the Honda from the impact with the right plane of the Geo



Figure 4: View west to area of the Honda's rollover

responders and was transported by ground ambulance to a hospital where she was treated in the emergency room for minor injuries and released. The driver and passenger of the Geo were transported by ground ambulance to a hospital. Both vehicles were towed from the crash scene due to damage.

## **2006 HONDA CR-V EX**

### **DESCRIPTION**

The Honda was a front-wheel drive, 5-passenger, 4-door sport utility vehicle (VIN: SHSRD78866Uxxxxxx) that was manufactured in June 2006. The vehicle was equipped with a 2.4-liter I-4 engine, a 5-speed automatic transmission, 4-wheel anti-lock disc brakes with electronic brake force distribution, braking assist, traction control, and Electronic Stability Control (ESC). The frontal air bags were certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) NO. 208. The Honda was also equipped with front seat-mounted side impact air bags, roof side rail-mounted rollover/side impact IC air bags, front safety belt pretensioners, and a tilt steering column that was adjusted to the center position. The windshield glazing was AS1 laminated, while the left and right front glazing were AS2 tempered. The remaining glazing was AS3 tempered-tinted (original). Prior to the crash, all of the glazing was either closed or fixed. The driver estimated that the vehicle's mileage was 136,795 kilometers (85,000 miles). The specified wheelbase was 262 cm (103.2 in).

The vehicle manufacturer's recommended tire size was P215/65R16. The vehicle manufacturer's recommended cold tire pressure for the front and rear tires was 200 kPa (29 psi). The tire data could not be determined. The wheels had been removed from the vehicle and sold prior to the SCI inspection.

The front row was equipped with cloth-covered bucket seats with adjustable head restraints. The second row was equipped with a cloth-covered bench seat with folding backs and adjustable head restraints. The driver's seat track was adjusted to between the middle and forward positions and the seat back was reclined 15 degrees. The top of the driver's head restraint was adjusted 22 cm (8.7 in) above the top of the seat back.

### **EXTERIOR DAMAGE**

***Exterior Damage Event 1:*** The Honda sustained damage to the front plane during the impact with the right plane of the Geo. The front bumper, right headlamp/turn signal assembly, hood, and grille were directly damaged. The direct damage began at the front right bumper corner and extended 69 cm (27.2 in) across the front plane. The front bumper had been removed so the crush measurements were taken at the lower radiator frame support. The maximum residual crush was 35 cm (13.7 in) located 11 cm (4.3 in) left of C<sub>5</sub>. The Field L was 99 cm (39 in). The crush values were: C<sub>1</sub>= 14 cm (5.5 in), C<sub>2</sub>= 15 cm (5.9 in), C<sub>3</sub>=22 cm (8.7 in), C<sub>4</sub>= 31 cm (12.2 in), C<sub>5</sub>= 28 cm (11 in), C<sub>6</sub>= 25 cm (9.8 in).

**Damage Classification Event 1:** The Collision Deformation Classification (CDC) was 11FZEW2 (330 degrees). The missing Vehicle Algorithm of the WinSMASH program calculated the total Delta V as 35 km/h (21.7 mph). The longitudinal and lateral velocity changes were -30 km/h (-18.6 mph) and 18 km/h (11.2 mph), respectively. The results appeared reasonable.

**Exterior Damage Event 2:** The left plane sustained direct damage during the rollover from contact with the roadway pavement. The direct damage began 35 cm (13.8 in) forward of the bottom of the right A-pillar and extended 334 cm (131.5 in) rearward along the left plane (**Figure 5**). The last three quarter turns of the rollover occurred on the grass covered roadside and there was no direct damage on the top and right planes. The maximum lateral crush was approximately 2 cm (0.8 in) occurring at the top of the left A-pillar (**Figure 6**). There was no vertical crush to the roof.

**Damage Classification Event 2:** The CDC for the rollover was 00LDAO2. Based on the extent of the crush, the severity of the damage was minor.

**EVENT DATA RECORDER**

The Honda's Air Bag Control Module (ACM) was removed from the vehicle and submitted to NHTSA headquarters for forwarding to the manufacturer and imaging of the Event Data Recorder (EDR) data. No data was returned from the manufacturer.

**INTERIOR DAMAGE**

The interior of the Honda sustained minor damage from air bag deployments and intrusion. The left A-pillar intruded approximately 1 cm (0.4 in) into the driver's space. There was blood transfer on the upper left quadrant of the driver's deployed frontal air bag. There was no other discernable evidence of occupant contact and no deformation of the steering wheel.

All the doors and the tailgate remained closed and operational. The windshield was cracked from impact forces. The left front and second left glazing were disintegrated from impact forces. The remaining glazing was undamaged.



**Figure 5:** Damage to the left plane of the Honda from the rollover



**Figure 6:** The maximum lateral crush to the Honda's roof structure occurred at the top of the left A-pillar



The front row was equipped with driver and front right passenger lap-and-shoulder safety belts. The driver's safety belt was equipped with continuous loop belt webbing, a sliding latch plate, an Emergency Locking Retractor (ELR), and an adjustable upper anchor that was in the full-down position. The front right passenger's safety belt was equipped with continuous loop belt webbing, a sliding latch plate, a switchable ELR/Automatic Locking Retractor (ALR), and an adjustable upper anchor that was in the full-down position. The front safety belts were also equipped with retractor-mounted and buckle-mounted pretensioners. The driver's pretensioners actuated and the buckle-mounted pretensioner was shortened 12 cm (4.7 in). The front right passenger's pretensioners did not actuate. The second row was equipped with lap-and-shoulder safety belts, which were equipped with continuous loop belt webbing, sliding latch plates, switchable ELR/ALRs, and non-adjustable upper anchors. The second row outboard seating positions were also equipped with Lower Anchors and Tethers for Children (LATCH).

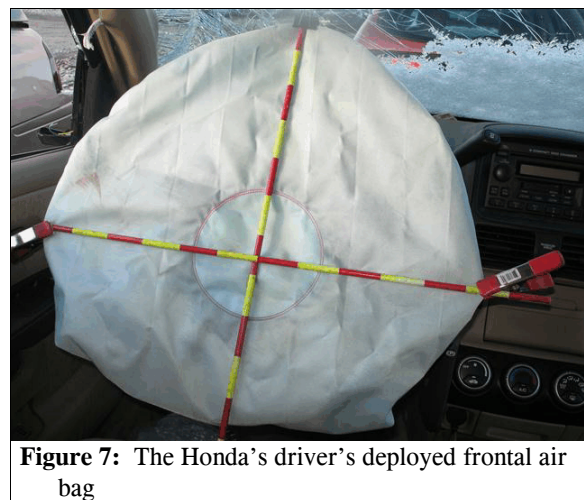
The driver stated during the SCI interview that she was restrained at the time of the crash. Inspection of the driver's safety belt assembly revealed that the retractor was jammed from pretensioner actuation with the safety belt spooled-out consistent with usage during the crash.

#### SUPPLEMENTAL RESTRAINT SYSTEMS

The Honda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual-stage driver and front right passenger air bags, driver seat track position sensor, safety belt buckle switch sensors, buckle-mounted and retractor-mounted pretensioners, and a front right passenger weight sensor. The driver's frontal air bag deployed in this crash. There was no front passenger and deployment of the passenger's air bag was suppressed.

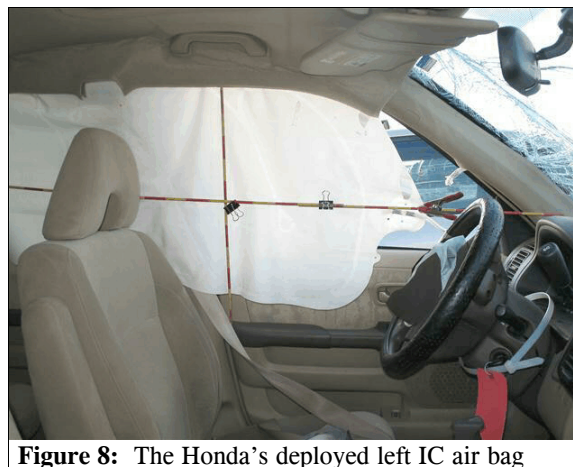
The vehicle was also equipped with roof side rail-mounted rollover/side impact IC air bags and front seat-mounted side impact air bags. The left and right IC air bags deployed in this crash. Neither front seat-mounted side impact air bag deployed in the crash.

The driver's frontal air bag was located within the steering wheel hub. The air bag module cover was a two-flap configuration constructed of pliable vinyl. The top flap was 16 cm (6.3 in) in width and 7 cm (2.8 in) in height. The bottom flap was 16 cm (6.3 in) in width and 6 cm (2.4) in height. The cover flaps opened at the designated tear seams and were undamaged. The deployed air bag (**Figure 7**) was 59 cm (23.2 in) in diameter and had two 5 cm (2 in) diameter vent ports on the back of the air bag at the 11 and 1 o'clock positions. There were also two internal tethers sewn to the center of the air bag. Each tether was 7 cm (2.8 in) wide. A blood transfer



was located on the upper left quadrant of the air bag. There was no other discernable evidence of occupant contact and no damage to the air bag.

The IC air bags were located along the roof side rails inside the headliner and extended from the A-pillar to the C-pillar. The deployed left IC air bag (**Figure 8**) was 167 cm (65.7 in) in width and 46 cm (18.1 in) in height. It was attached to the A-pillar by a 15 cm (5.9 in) long nylon tether and to the roof side rail between the C- and D-pillars by a 27 cm (10.6 in) long tether. The gap between the front of the IC air bag and the window frame at the beltline was 32 cm (12.9 in). The distance the IC air bag extended below the beltline was 12 cm (4.7 in). There was no discernable evidence of occupant contact and no damage. The right IC air bag was of the same features and dimensions. The right IC air bag sustained no damage during the crash.



**Figure 8:** The Honda's deployed left IC air bag

## ROLLOVER MITIGATION

The Honda's rollover mitigation features consisted of ESC and rollover sensing. The ESC uses sensors to detect a loss of steering control and selectively applies the brakes to minimize a control loss and keep the vehicle on the intended path. ESC did not apply in this crash since no pre-crash control loss occurred. The rollover sensor considers the roll angle, rate of roll, and speed to determine an impending rollover situation and deploy the IC air bags. The specific threshold for deploying the IC air bags for the Honda is not known.

The NHTSA has given this vehicle model a four star rollover rating on a five star scale<sup>1</sup>. The rollover star rating is determined based on a static measurement and a dynamic test for rollover. The static measurement is a mathematical calculation considering the vehicle's weight, track width, and height of the center of gravity and is referred to as the Static Stability Factor. The dynamic test is conducted with a weighted vehicle that simulates a load of five passengers and a full tank of gas. The test vehicle is driven to simulate an emergency lane change. If instruments detect two tires that lift at least 5 cm (2 in), then the vehicle is considered to have "tipped up," which is the precursor to a rollover. The four star rating for the Honda indicates that the vehicle has a 10-20% chance of a rollover.

The rollover of the Honda occurred following the frontal impact with the right plane of the Geo. The impact caused the Honda to rotated clockwise approximately 110 degree as the vehicle traveled approximately 16 m (53 ft) and the friction between the left side tires and pavement caused it to roll over, left side leading, four quarter turns. The left plane of the vehicle slid on the roadway during the first quarter turn. The vehicle then departed the right side of the roadway and continued to roll over on the grass covered roadside an additional three quarter turns. There

<sup>1</sup> [www.safercar.gov](http://www.safercar.gov), 1/11/12

were no gouge marks or tire marks present on the roadway and the area of rollover initiation was estimated. The distance traversed during the rollover was approximately 11 m (36 ft). The vehicle came to final rest on its wheels on the right side of the roadway at the bottom of an embankment heading north.

The Honda's IC air bags deployed during the rollover. The IC air bags were designed to mitigate the ejection of an occupant by remaining inflated longer and providing coverage of the window openings. The restrained driver remained within the vehicle throughout the rollover.

**2006 HONDA CR-V EX OCCUPANT**

**DRIVER DEMOGRAPHICS**

Age/Sex: 70 years/female  
 Height: 160 cm (63 in)  
 Weight: 77 kg (170 lbs)  
 Eyewear: No  
 Seat Type: Bucket  
 Seat Track Position: Between forward and middle  
 Manual Restraint Usage: Lap-and-shoulder belt  
 Usage Source: Vehicle inspection  
 Air Bags: Frontal, deployed; left IC, deployed; side impact, not deployed  
 Alcohol/Drug Involvement: None  
 Egress from Vehicle: Exited with assistance of emergency responders  
 Transport from Scene: Ground ambulance  
 Medical Treatment: Treated in hospital emergency room and released

**DRIVER INJURIES**

Injury Number	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Abrasion, superficial, to forehead above right eye	210202.1,7	Air bag, driver's	Probable
2	Contusion (hematoma), large, on forehead over right eye	210402.1,7	Air bag, driver's	Probable
3	Contusion (periorbital) right eye	210402.1,1	Air bag, driver's	Probable
4	Abrasion dorsum (on top of) right hand, extending from knuckles to wrist	710202.1,1	Air bag, driver's	Probable
5	Contusion right hand, not further specified	710402.1,1	Air bag, driver's	Probable
6	Contusion, 20.3 cm (8 in) left knee extending onto inside of lower leg	810402.1,2	Left lower instrument panel (includes knee bolster), left of steering column	Probable

*Sources: Emergency Room Records and Interviewee Data—Same Person. Injury Numbers 1 and 5 came only from Emergency Room Records. Injury Numbers 4 and 6 came from Interviewee Data. Injury Numbers 2 and 3 came from a combination of ER Records and Interviewee Data.*

## **DRIVER KINEMATICS**

The driver was restrained by the lap-and-shoulder safety belt and seated in an upright posture. The seat track was adjusted to between the forward and middle positions and the seat back was reclined 15 degrees. The top of the head restraint was adjusted 22 cm (8.7 in) above the top of the seat back. The frontal impact to the Honda actuated the driver's safety belt pretensioners and deployed the driver's frontal air bag. The driver was displaced forward and to the left opposite the 11 o'clock direction of force. The driver's face, chest and right hand loaded the deployed frontal air bag, which caused contusions and abrasions on the forehead, a contusion to the right eye, and an abrasion on the top of the right hand, which extended from the knuckles to the wrist. The driver's left knee also contacted the lower left instrument panel causing a contusion on the knee, which extended onto the inside of the lower leg. The driver was redirected to the left and toward the roof within the safety belt when the vehicle rolled over, left side leading. While the driver's head probably loaded the deployed left IC air bag during the rollover, no discernable evidence of occupant contact was found on the IC air bag. The driver exited the vehicle with the assistance of emergency responders and was transported by ground ambulance to a hospital. She was treated in the emergency room and released.

## **1990 GEO PRIZM**

### **DESCRIPTION**

The Geo was a front wheel drive, 5-passenger, 4-door sedan (VIN: unknown) equipped with a 1.6 liter, I-4 engine and either a standard 5-speed manual or the optional 3-speed automatic transmission, and frontal air bags. The Geo was not equipped with anti-lock brakes.

### **EXTERIOR DAMAGE**

The Geo was not inspected. The vehicle sustained damage to the right plane. The missing Vehicle Algorithm of the WinSMASH program calculated the total Delta V for the Geo as 48 km/h (29.8 mph). The longitudinal and lateral velocity changes were -37 km/h (-23 mph) and -31 km/h (-19.3 mph), respectively. The results should be considered borderline.

### **OCCUPANT DATA**

The driver of the Geo (17-year-old male) and front right passenger (13-year-old female) were restrained by their lap-and-shoulder safety belts according to the police crash report. The driver sustained a police reported "B" (non-incapacitating) injury and the passenger sustained a "C" (possible) injury. The driver and passenger were transported by ground ambulance to a hospital. Their injury and treatment status was not determined.

