

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE HYBRID VEHICLE CRASH INVESTIGATION
SCI CASE NO: CA08024**

**VEHICLE: 2000 HONDA INSIGHT
LOCATION: PENNSYLVANIA
CRASH DATE: MAY, 2008**

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

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

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16. Abstract This investigation focused on the crash dynamics and crash severity surrounding the intersection crash of a 2000 Honda Insight and a 2007 Subaru Impreza. The Honda Insight was a gasoline-electric hybrid vehicle powered by a 1.0 liter, in-line three-cylinder internal combustion engine and a 54 kilowatt electric motor. The vehicle's electrical power was supplied by a 144 volt DC nickel-metal hydride battery located behind the rear seat. The Honda was equipped with redesigned front air bags for the driver and front right passenger that did not deploy as a result of the impact. There was no damage to the hybrid battery compartment. This crash occurred at the four-leg intersection of a five-lane north/south road and a three-lane east/west road. The intersection was controlled by overhead traffic signals. The crash occurred when the 72 year old restrained male driver of the northbound Honda initiated a left turn across the path of the southbound Subaru. The Subaru was driven by a 25 year old restrained male. The front plane of the Subaru struck the right frontal area of the Honda in an 11/1 o'clock impact configuration. The Honda was redirected in a southwest trajectory and separated from the impact with a counterclockwise rotation. The vehicle came to rest within the southbound travel lane facing southwest. The Subaru was deflected to its right and came to rest facing southwest on the west leg of the intersection. The drivers were able to exit their respective vehicles under their own power and were not injured.					
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BACKGROUND

This investigation focused on the crash dynamics and severity surrounding the intersection crash of a 2000 Honda Insight and a 2007 Subaru Impreza. The Honda Insight was a gasoline-electric hybrid vehicle powered by a 1.0 liter, in-line three-cylinder internal combustion engine and a 54 kilowatt electric motor. The vehicle's electrical power was supplied by a 144 volt DC nickel-metal hydride battery located behind the rear seat. The Honda was equipped with redesigned front air bags for the driver and front right passenger that did not deploy as a result of the impact. There was no damage to the hybrid battery compartment.



Figure 1: Front view of the Honda.

This crash occurred at the four-leg intersection of a five-lane north/south road and a three-lane east/west road. The intersection was controlled by overhead traffic signals. The crash occurred when the 72 year old restrained male driver of the northbound Honda initiated a left turn across the path of the southbound Subaru. The Subaru was driven by a 25 year old restrained male. The front plane of the Subaru struck the right frontal area of the Honda in an 11/1 o'clock impact configuration. The Honda was redirected in a southwest trajectory and separated from the impact with a counterclockwise rotation. The vehicle came to rest within the southbound travel lane facing southwest. The Subaru was deflected to its right and came to rest facing southwest on the west leg of the intersection. The drivers were able to exit their respective vehicles under their own power and were not injured.

This crash was identified by the Crash Investigation Division of the National Highway Traffic Safety Administration through a review of police reported crashes sampled by the General Estimates System (GES). An on-site investigation of the crash was assigned to the Calspan Special Crash Investigations (SCI) team on June 24, 2008 due to the agency's interest in hybrid vehicle technology. Calspan SCI initiated follow-up investigation and established cooperation with the respective insurance agencies. The Honda was available for inspection at an insurance auction facility and was inspected on June 26, 2008. The Subaru was repaired by the vehicle's owner prior to SCI notification and was not inspected.

SUMMARY

VEHICLE DATA

2000 Honda Insight

The 2000 Honda Insight was identified by the Vehicle Identification Number: JHMZE1352YT (production sequence deleted). This two door/two passenger gasoline/electric hybrid vehicle was manufactured in September 2000. The digital odometer reading at the time of the SCI inspection was not determined. The power train consisted of a 1.0 liter three-cylinder engine and a 54 kilowatt electric motor coupled to a five-speed manual transmission. The electric motor was powered by a 144 volt DC nickel-metal hydride battery located under the cargo floor behind the seats. During coasting and braking, the electric motor also served as a generator to recharge the batteries. The vehicle was engineered for low drag/low weight and had an all aluminum body. The brakes were a conventional front disc/rear drum system with four-wheel anti-lock (ABS). The interior was configured with two manually adjusted bucket seats, three-point lap and shoulder safety belts and frontal air bags. The air bags did not deploy in the angular crash. The vehicle was equipped with low-rolling resistance Bridgestone Protenza RE92 P165/65SR14 tires mounted on OEM alloy rims. The vehicle manufacturer's recommended cold tire pressure was 260 kPa (38 PSI) front and 240 kPa (35 PSI) rear. The specific measured tire data and the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	241 kPa (35 PSI)	6 mm (7/32 in)	No	None
LR	241 kPa (35 PSI)	5 mm (6/32 in)	No	None
RF	255 kPa (37 PSI)	6 mm (7/32 in)	No	None
RR	234 kPa (34 PSI)	5 mm (6/32 in)	No	None

2007 Subaru Impreza

The 2007 Subaru Impreza was identified by the Vehicle Identification Number: JF1GG74647G (production sequence deleted). This all-wheel drive, four-door station wagon was configured with a 2.5 liter I4 engine linked to a four-speed automatic transmission. The service brakes were a front and rear disc system with ABS. The Subaru was equipped with manual three-point lap and shoulder safety belts. The front safety belts were equipped with retractor pretensioners. The Subaru Impreza was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system and an inflatable side impact protection system. The CAC system in the Subaru was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switches, front safety belt buckle pretensioners, and a front right occupant detection sensor. The frontal air bags in the vehicle were certified by the vehicle manufacturer to be compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The inflatable side impact protection system consisted of front seat back mounted side impact (thorax) air bags and roof-rail mounted inflatable side impact curtains. None of the air bags in the Subaru deployed in the crash. The Subaru was repaired by the owner prior to SCI notification of the crash and was not inspected.

CRASH SITE

This two-vehicle crash occurred during the daylight hours of May 2008. At the time of the crash, it was raining and the asphalt road surface was wet. The crash occurred at the four-leg intersection on a five-lane north/south road and a three-lane east west road. The north/south road was configured with two travel lanes in the respective directions and a center left turn lane. The intersection was controlled by standard (red/amber/green) overhead traffic signals. There was a positive three percent (+3%) grade through the intersection in the northbound direction. The speed limit in the area of the crash was 56 km/h (35 mph). **Figures 3 and 4** are trajectory views of the Honda and Subaru, respectively.



Figure 2: Northbound trajectory view of the Honda.



Figure 3: Southbound trajectory view of the Subaru.

CRASH SEQUENCE

Pre-Crash

The Honda Insight was northbound in the center turn lane driven by a 72 year old restrained male. It was the driver's intention to turn left at the intersection and travel west. The Subaru Impreza was southbound in the outboard lane driven by a 25 year old restrained male. The driver of the Subaru intended to continue south through the intersection. The crash occurred when the Honda turned left across the path of the Subaru. Both drivers indicated to the investigating police officer that the traffic signal was on the green phase for north/south traffic.

Crash

The front plane of the Subaru impacted the right frontal area of the Honda in an 11/1 o'clock impact configuration. The force of the angular impact deformed the bumper reinforcement beam and sheared the Honda's frontal structure that supported the beam from its mounting points. [Refer to the *Exterior Damage* section of this report for greater detail on the front structure and its damage.] The offset impact force caused the vehicle to rotate counterclockwise and redirected the Honda to the southwest. The Honda came to rest facing southwest partially blocking the southbound traffic lane. The Subaru was deflected to its right by the impact and separated with a southerly trajectory. The Subaru came to rest facing south on the west leg of the intersection. **Figure 8** at the end of this report is a schematic of the crash.

Due to nature of the non-central collision and the shear-mode deformation of the Honda's front structure, an analysis of the impact utilizing the WINSMASH model was not appropriate. This impact violated the basic assumptions used to derive the model. The severity of the impact was based on SCI field experience. That field experience indicated the delta V of the Honda was approximately 16 to 19 km/h (10 to 12 mph).

Post-Crash

The drivers of both the Honda and Subaru exited their respective vehicles unassisted. Neither driver was injured or required medical treatment. The police arrived on the scene and conducted an investigation. Both vehicles sustained disabling damage and were towed from the crash site. The Honda Insight was deemed a total loss and was taken to an insurance salvage yard where it was inspected for this SCI investigation. The Subaru was subsequently repaired and returned to service prior to SCI notification of the crash.

2000 HONDA INSIGHT

Exterior Damage

The front plane of the Honda sustained a combined width of direct contact and induced damage that extended across the vehicle's entire 147 cm (58 in) end width. The direct contact damage began at the right front corner and extended laterally across the front plane 95 cm (37.5 in). The direct damage ended 20 cm (8 in) left of center as measured on the hood face. Refer to **Figure 4**. The direct contact extended 18 cm (7 in) longitudinally onto the hood. The bumper fascia could not be inspected as it had separated during the impact and was not with the vehicle. The bumper reinforcement beam consisted of a 63 mm x 76 mm (2.5 in x 3 in) aluminum box beam that was 109 cm (43 in) in length. It was observed that the beam was fractured 13 cm (5 in) right of center and deformed in an inverted V-pattern. The entire reinforcement beam and its mounting structure had separated from the vehicle at its mounting point. This mounting structure was a design unique to the Insight. The reinforcement beam was attached to the vehicle's sub-frame by two aluminum stand-offs. Each stand-off was a formed hexagonal structure measuring 9 cm (3.5 in) in diameter and 29 cm (11.3 in) long. The stand-offs were attached to the sub-frame by a hexagon bolt pattern. The angular impact force caused a shearing deformation of the aluminum at the bolted connection. **Figure 5** is an overall view of the structure of the bumper reinforcement. **Figure 6** is a close-up view of the right stand-off. There was no crush of the stand-offs and no measureable crush at the sub-frame mounts. There was no measureable change in either wheelbase dimension. Both doors were operational. The windshield was not fractured and all the side glazing was intact. The Collision Deformation Classification (CDC) was determined to be 01-FZEW1.



Figure 4: View of the frontal damage.



Figure 5: View of the bumper reinforcement structure.

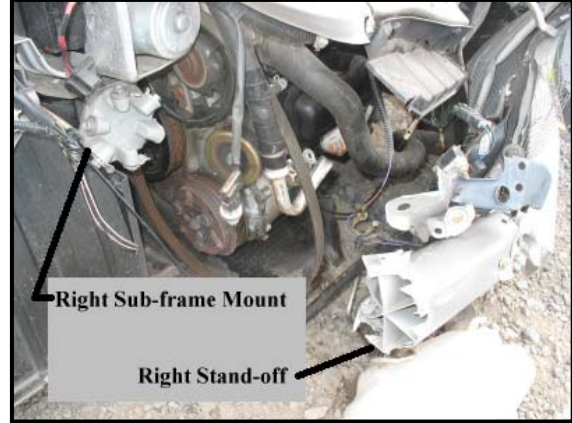


Figure 6: Close-up view of the right stand-off and sub-frame mount.

Interior Damage

There was no interior damage or intrusion within the occupant compartment of the Honda. No points of occupant contact were present. **Figure 7** is an interior view of the Honda.

The manual driver seat was adjusted to the full rear track position. The total seat track travel measured 23 cm (9 in). The seat back was reclined 10 degrees aft of vertical. A sheep-skin seat cover was in place covering the cloth driver's seat. The horizontal distance between the seat back and the driver air bag module located in the center of the steering wheel rim measured 60 cm (23.5 in). There was no displacement of the steering column's shear capsules.



Figure 7: Interior view of the Honda.

Manual Restraint Systems

The manual restraint systems in the Honda consisted of three-point lap and shoulder safety belts. The driver's restraint was comprised of a continuous loop webbing, a sliding latch plate, a fixed D-ring and an Emergency Locking retractor (ELR). The webbing was stowed on the retractor upon initial observation. The inspection of the restraint system revealed historical use evidence. The webbing was creased and a 10 cm (4 in) section of the appeared to be stretched. This stretching was located 74 cm (29 in) above the outboard anchor and identified the location of the latch plate in the buckled condition. The evidence identified on the restraint during the SCI inspection indicated the driver was restrained at the time of the crash.

Air Bag Systems

The Honda Insight was equipped with redesigned driver and front right passenger air bags. The air bags did not deploy during the crash sequence. The driver air bag was housed within the center hub of the steering wheel rim. The front right passenger air bag was housed in the right aspect of the instrument panel.

Battery Storage Compartment

The battery storage compartment in the Honda Insight was located aft of the front seats above the rear axle. The compartment measured approximately 53 cm x 91 cm x 23 cm (21 in x 36 in x 9 in), length x width x height, respectively. The compartment was sealed by an aluminum cover that was bolted in place. There was no damage to the compartment. A storage well was located rearward of the battery compartment. The spare tire was housed below the storage well, under the level of the battery compartment. **Figures 8 – 11** are a series of images of the Insight's cargo area and battery compartment.



Figure 8: Rear view into the cargo area.



Figure 9: View of the battery compartment location.



Figure 10: Battery compartment and storage well.



Figure 11: Spare tire location.

HONDA DRIVER DEMOGRAPHICS/DATA

Age/Sex: 72 year old/Male
Height: 170 cm (67 in)
Weight: 64 kg (140 lb)
Seat Track Position: Full rear track
Safety Belt Use: Three-point lap and shoulder
Usage Source: SCI inspection
Egress from Vehicle: Exited unassisted from left front door
Mode of Transport
From Scene: None
Type of Medical Treatment: None, not injured

DRIVER INJURIES

<i>Injury</i>	<i>Injury Severity (AIS 90/Update 98)</i>	<i>Injury Source</i>
Not injured	N/A	N/A

DRIVER KINEMATICS

The 72 year old male driver of the Honda Insight was restrained at the time of the crash. The driver was initially stopped at a red traffic signal. When the traffic signal cycled to the green phase for north/south travel, he accelerated forward to a driver estimated speed of 16 km/h (10 mph) and began to execute a left turn when the angular crash occurred. At impact, the inertial locking retractor locked the safety belt. The driver initiated a forward and right trajectory in response to the 1 o'clock direction of the impact force and loaded the locked belt system. The driver continued to load the safety belt as the Insight slid to final rest and rode down the force of the crash. He then rebounded back into his seat and came to rest. He was not uninjured during the event.

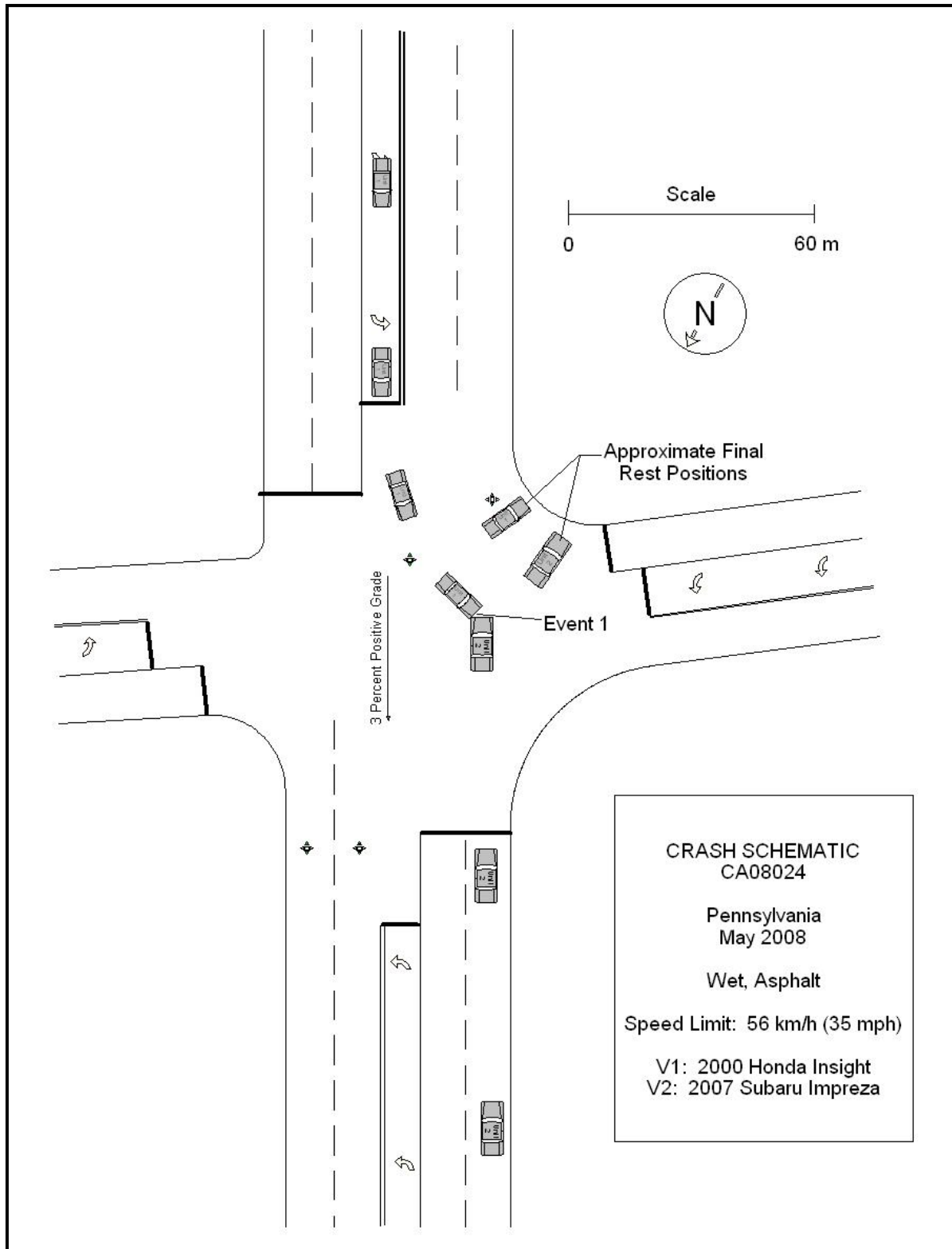


Figure 12: Crash schematic.