

On Site Hybrid Vehicle Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS03029
2003 Honda Civic Hybrid
California
June, 2003

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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 crash-worthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. Report No. DS03029	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle On Site Hybrid Vehicle Investigation			5. Report Date	
			6. Performing Organization Report No.	
7. Author(s) Dynamic Science, Inc.			8. Performing Organization Report No.	
9. Performing Organization name and Address Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401			10. Work Unit No. (TRAVIS)	
			11. Contract or Grant no. DTNH22-01-C-27002	
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590			13. Type of report and period Covered [Report Month, Year]	
			14. Sponsoring Agency Code	
15. Supplemental Notes				
16. Abstract This two vehicle case occurred in June, 2003 at 1612 hours in southern California. This crash took place in the westbound approach to a four leg intersection. The speed limit was 72 km/h (45 mph). The case vehicle is a 2003 Honda Civic Hybrid gasoline-electric hybrid four door sedan driven by a lap and shoulder restrained 51-year-old male. The Civic Hybrid uses Honda's Integrated Motor Assist (IMA) technology—a 1.3-liter 4-cylinder gasoline engine coupled with a high output electric motor. The other vehicle is a 1990 Chevrolet Suburban sport utility vehicle driven by a lap and shoulder restrained 31-year-old female. There were three additional occupants in this vehicle. The case vehicle had slowed and then stopped for a red light in the first lane from the right facing west. The other vehicle was in the same lane and traveling at a police estimated speed of 48 km/h (30 mph). The driver of the other vehicle did not see the light change until it was too late. The driver braked but was unable to stop. The front of the other vehicle struck the rear of the case vehicle. There were no reported injuries. The case vehicle was towed from the scene due to damage and was subsequently declared a total loss by the insurance company. There were no indications of any damage to the engine or the rear mounted battery pack. The other vehicle was driven from the scene.				
17. Key Words Hybrid vehicle, gasoline/electric, crash, rear impact, non-injury			18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price	

Form DOT F 1700.7 (8_72) Reproduction of this form and completed page is authorized

Dynamic Science, Inc.
Crash Investigation
Case Number: DS03029

TABLE OF CONTENTS

Background	1
Description	1
Investigation Type	1
Crash Location	1
Crash Date	1
Notification Date	1
Field Work Completed	1
Summary	1
Crash Site	1
Pre-crash	1
Crash	2
Post-crash	3
Vehicle Data - 2003 Honda Civic Hybrid	4
Vehicle Damage	5
Exterior Damage	5
Interior Damage	6
Manual Restraint Systems	6
Air Bag System	6
IMA Discussion - 2003 Honda Civic Hybrid	8
Electric-powered vehicles: electrolyte spillage and electrical shock protection	9
Vehicle Data - 1990 Chevrolet Suburban	10
Occupant Demographics	11
Occupant Injuries	14
Occupant Kinematics	15
Attachment 1. Scene Diagram	16
Attachment 2. Electrical Isolation Test Discussion	17

BACKGROUND:

Description: This Hybrid Vehicle case was identified by DSI through existing insurance contacts. The National Highway Traffic Safety Administration (NHTSA) was notified on September 24, 2003. DSI was assigned the case on September 25, 2003. Field work was completed on September 26, 2003.

Investigation Type: On Site Hybrid Vehicle Investigation
Crash Location: California
Crash Date: June, 2003
Notification Date: September 25, 2003
Field Work Completed: September 26, 2003

SUMMARY

Crash Site

This two vehicle case occurred in June, 2003 at 1612 hours in southern California. This crash took place in the westbound approach to a four leg intersection. The undivided roadway is comprised of three westbound travel lanes, two left hand turn lanes, and three eastbound travel lanes. The asphalt roadway is level and was dry at the time of the crash. The intersection is controlled by tri-color traffic signals. The speed limit is 72 km/h (45 mph).

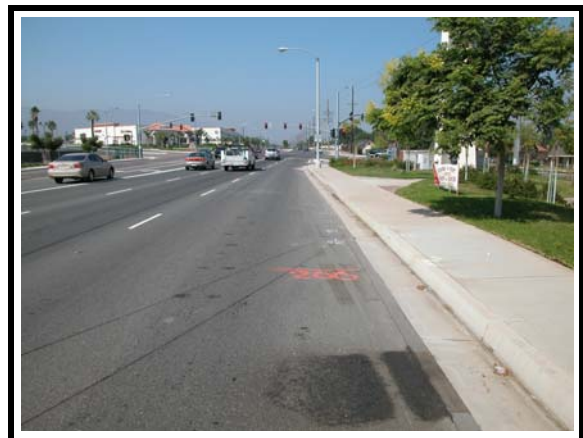


Figure 1. Approach of both vehicles to area of impact (westbound)

Pre-Crash

The case vehicle is a 2003 Honda Civic Hybrid gasoline-electric hybrid four door sedan driven by a lap and shoulder restrained 51-year-old male (178 cm/70 in, 75 kg/165 lbs). The driver was wearing prescription glasses. The Civic Hybrid uses Honda's Integrated Motor Assist (IMA) technology—a 1.3-liter 4-cylinder gasoline engine coupled with a high output electric motor. The system's nickel metal hydride battery module is automatically recharged during braking and deceleration. The case vehicle was equipped with a driver's air bag, a front right passenger air bag, front seat back mounted side air bags, and front seat belt pretensioners. There were no air bag deployments and the seat belts pretensioners did not actuate.

The other vehicle is a 1990 Chevrolet Suburban sport utility vehicle driven by a lap and shoulder restrained 31-year-old female. There were three additional occupants in this vehicle. The rear left seat was occupied by a 2-year-old male seated in a child safety seat. The rear middle seat was occupied by a lap and shoulder belt restrained 10-year-old female. The rear right seat was occupied by a lap and shoulder restrained 9-year-old female.

The case vehicle had slowed and then stopped for a red light in the first lane from the right facing west. The other vehicle was in the same lane and traveling at a police estimated speed of 48 km/h (30 mph). The driver of the other vehicle did not see the light change until it was too late. The driver braked but was unable to stop.

Crash

The left front of the other vehicle struck the right rear of the case vehicle (06BREW2). The total velocity change as calculated by the missing vehicle algorithm of WinSmash collision model was 15.0 km/h (9.3 mph). The longitudinal and lateral delta V components were 15.0 km/h (9.3 mph) and 0 km/h (0 mph), respectively.



Figure 2. Left rear of case vehicle



Figure 3. Right rear bumper corner

Post-Crash

There were no reported injuries.

The case vehicle was towed from the scene due to damage and was subsequently declared a total loss by the insurance company. There were no indications of any damage to the engine or the rear mounted battery pack.

The other vehicle was driven from the scene.



Figure 4. Interior view from right side

VEHICLE DATA -2003 Honda Civic Hybrid

The Honda Civic Hybrid was a four-door sedan equipped with a continuously variable shiftless automatic transmission, cruise control, 4-wheel anti-lock braking system, a tilt steering column, power windows, and power door locks.

VIN: JHMES96653SXXXXXX
 Odometer: Unknown.
 Engine: 1.3L/4 cylinder
 Reported Defects: None
 Cargo: None

The 2002 Honda Civic Hybrid was equipped with Dunlop P185/70R14 All Season tires. There were no tire restrictions or tire damage. The specific tire data is as follows:

Tire	Tread (Measured)	Pressure (Measured)	Recommended pressure
LF	7 mm (9/32 in)	228 kPa (33 psi)	241 kPa (35 psi)
LR	6 mm (8/32 in)	241 kPa (35 psi)	241 kPa (35 psi)
RF	7 mm (9/32 in)	255 kPa (37 psi)	241 kPa (35 psi)
RR	6 mm (8/32 in)	228 kPa (33 psi)	241 kPa (35 psi)

The front seating positions in the 2002 Honda Civic Hybrid were equipped with bucket seats with adjustable head restraints. The driver side had a manual seat height adjusted. Both front seats were slightly reclined at the time of inspection. The rear seating positions were configured with a bench seat with integral head restraints for the outboard positions.

VEHICLE DAMAGE

Exterior Damage - 2003 Honda Civic Hybrid

Damage Description: Moderate rear end damage. Backlight disintegrated. Vehicle towed from the scene. Declared a total loss by insurance company.

CDC: 06BREW2

Delta V:	Total	15.0 km/h (9.3 mph)
	Longitudinal	15.0 km/h (9.3 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	12,151 joules (8,962 ft-lbs)

The case vehicle sustained 43.0 cm (16.9 in) of direct contact damage across the back end beginning at the right rear bumper corner. The residual crush measured along the bumper was as follows: C1=0 cm (0 in), C2=0 cm (0 in), C3=1.0 cm (0.4 in), C4=26.0 cm (10.2 in). The C4 measurement was averaged with the crush found to the frame. The maximum crush was located at C4. The principle direction of force was within the 6 o'clock sector and was an estimated 180 degrees. The damaged components for this impact included the bumper fascia and reinforcement bar, the trunk lid, and the right rear quarter panel. The wheelbase retained its pre-crash dimensions.

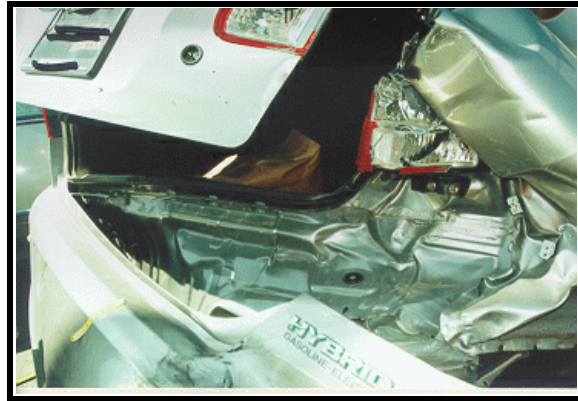


Figure 5. Right rear corner

Interior Damage - 2003 Honda Civic Hybrid

Interior damage to the Civic was almost non-existent. There was some light scuffing to the driver's head restraint that suggested a possible head contact. The backlight was disintegrated to impact forces.

MANUAL RESTRAINT SYSTEMS - 2003 Honda Civic Hybrid

The Civic was configured with manual 3-point lap and shoulder belts for both front positions and all three rear seat positions. The front seat restraints were configured with adjustable shoulder belt upper anchorages that had been adjusted to the full down position. All the seat belts were equipped with sliding latch plates. The driver's seat belt was equipped with an emergency locking retractor. The front right passenger's seat belt and all three rear seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats). The driver's seat belt was in use at the time of the crash.

AIR BAG SYSTEM - 2003 Honda Civic Hybrid

The Honda Civic was equipped with frontal air bags for the driver and front right passenger positions. The driver's air bag was housed in the steering wheel hub. The front right passenger's air bag was housed on top of the instrument panel. The front seats were also equipped side air bags that were housed in the seat backs. The front right passenger seat back was equipped with an occupant position detection system that can prevent a side air bag deployment if someone is leaning into the air bag deployment path. A dashboard warning light illuminates to alert the driver if the side air bag has been deactivated. There were no air bag deployments. The front seat belts were equipped with both buckle and B pillar pretensioners. There was no pretensioner actuation. See overview of system on the following page.



Figure 6. Driver's air bag/module

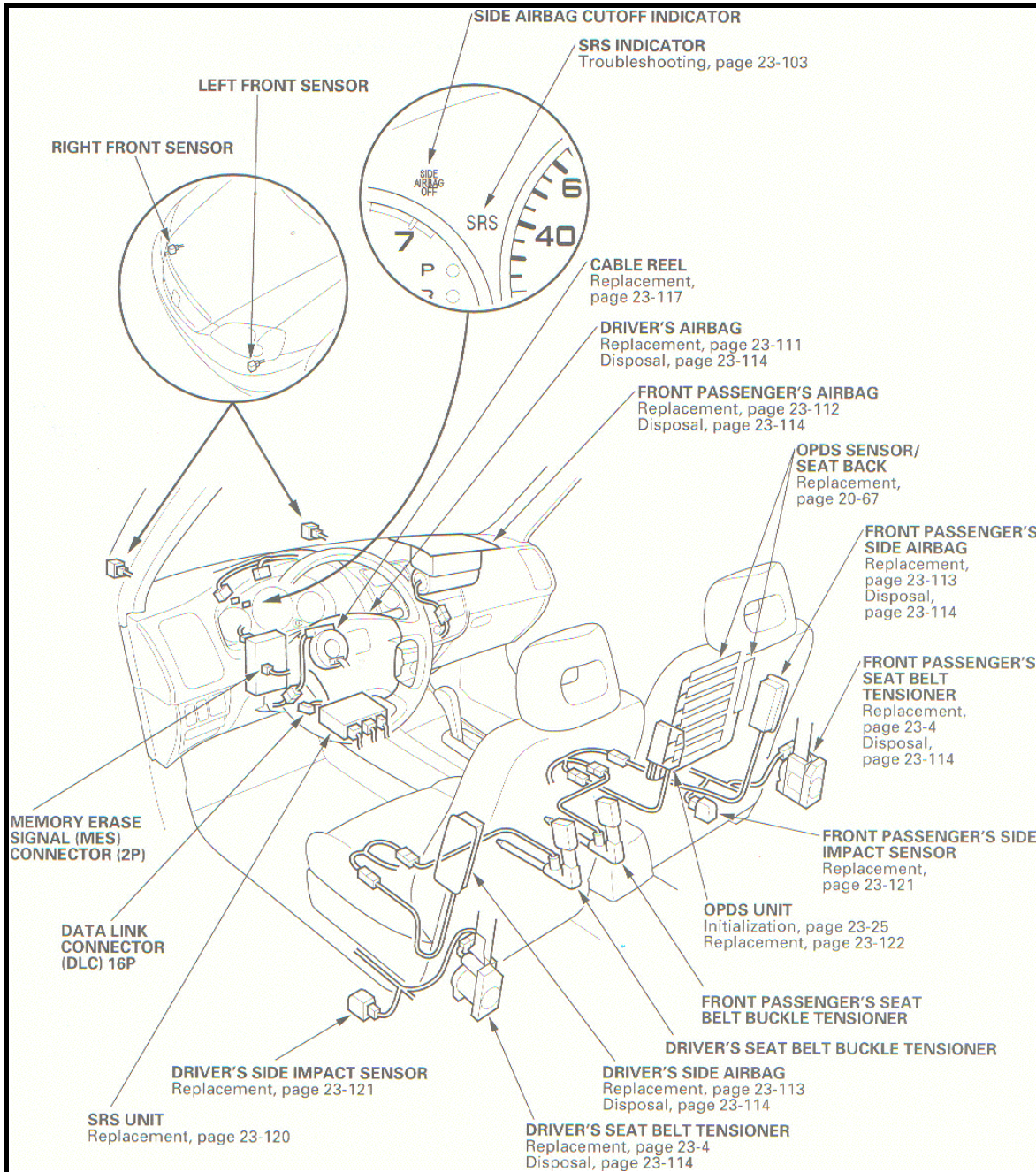


Figure 7. SRS Component Location Index, page 23-11, 2003 Civic Hybrid Service Manual

IMA Discussion - 2003 Honda Civic Hybrid

The IMA is composed of a gasoline engine and an electric motor. Located between the engine and transmission, the electric motor supplies additional power during acceleration. It also functions as a high-speed starter and as a generator for the charging system during regenerative braking. The IMA electric motor works in conjunction with the gasoline engine, and supplies additional torque in assist mode. It is powered by a 144 volt nickel metal hydride (NI-MH) battery pack, which is stowed at the back of the car (behind the rear seat) and consists of 120 cells providing 1.2 volts each. The engine and electric motor operate together under the following modes:

- Starting is normally done by the IMA. If the IMA battery pack charge is low, a separate 12-volt battery and starter motor are used.
- When the IMA system detects a demand for additional power, via the throttle position sensor, the electric motor starts and adds horsepower.
- When cruising at a steady speed the gasoline engine works by itself.
- When the driver is using the brakes, the electric motor becomes a generator, recharging the battery.
- At a stop, the engine cuts off automatically due to the idle-stop feature. It restarts itself when the vehicle is ready begin moving again.

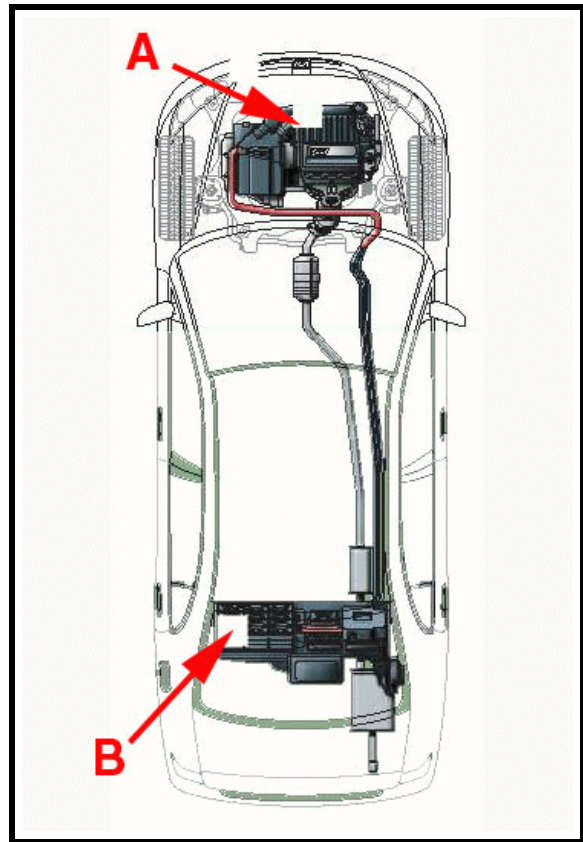


Figure 8. (A) Combination gasoline/electric powerplant, (B) Ni-MH battery pack

Compliance with Sec.571.305 Standard No.305; Electric-powered vehicles: electrolyte spillage and electrical shock protection

The case vehicle was examined to determine compliance with the 305 standards.

- There were no indications of electrolyte spillage from the propulsion battery.
- There was no movement of the battery module.
- The electrical isolation test could not be conducted. There were no indications of any arcing, fire, or component meltdown. See Attachment 2 for discussion of electrical isolation test.

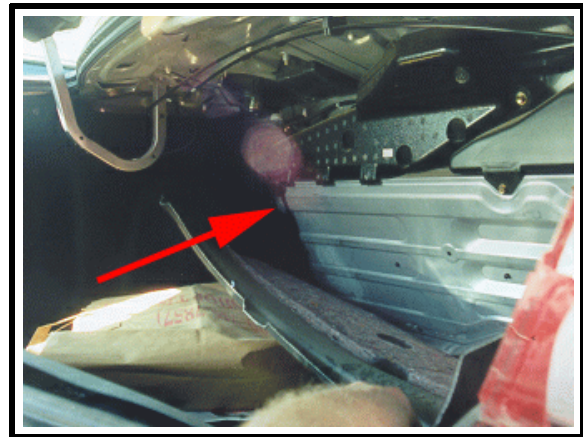


Figure 9. Battery pack, undamaged

Responding agency training

The responding officers did not have any EV specific training. Their academy does, however, provide limited hazardous materials training.

VEHICLE DATA - Chevrolet Suburban

Description:	1990 Chevrolet Suburban sport utility	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Minor front end damage. Vehicle driven from the scene by the driver.	
CDC:	Unknown	
Delta V:	Total	9.0 km/h (5.6 mph)
	Longitudinal	-9.0 km/h (-5.6 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	6,823 joules (5,033 ft-lbs)

OCCUPANT DEMOGRAPHICS - 2003 Honda Civic Hybrid

	Driver
Age/Sex:	51/Male
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat. Seat back slightly reclined. Seat at rear most track position.
Height:	178 cm (70 in)
Weight:	75 kg (165 lbs)
Occupation:	Teacher
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	30+ years
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, unknown position.
Foot Position:	Right foot on brake, left on floor
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Driver's air bag available, did not deploy

OCCUPANT DEMOGRAPHICS - 1990 Chevrolet Suburban

	Driver	Occupant 2
Age/Sex:	31/Female	2/Male
Seated Position:	Front left	Rear left
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Unknown	NA
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Presumed to be > 10 years	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available and used, per police	Seated in a child safety seat.

	Occupant 3	Occupant 4
Age/Sex:	10/Female	9/Female
Seated Position:	Rear middle	Rear right
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	NA	NA
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	NA	NA
Driving Experience:	NA	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available and used, per police	Lap and shoulder belt available and used, per police

OCCUPANT INJURIES -2003 Honda Civic Hybrid

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
<u>Driver:</u>	Not injured			

OCCUPANT INJURIES - other vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Not injured			
Rear left occupant:	Not injured			
Rear middle occupant:	Not injured			
Rear right occupant:	Not injured			

OCCUPANT KINEMATICS -2003 Honda Civic Hybrid

The 51-year-old male (178 cm/70 in, 75 kg/165 lbs) driver of the case vehicle was seated in a normal, upright fashion. The seat had been adjusted to the rear most track position. The seat back was slightly reclined. The head restraint was in the full down position. The driver was wearing the available 3-point lap and shoulder belt. The shoulder belt upper anchorage was adjusted to the full down position. Both of his hands were on steering wheel. His right foot was on the brake, the left on the floor.

At impact, the driver responded to the 6 o'clock direction of force by moving rearward engaging the seat back and the head restraint. There were scuffs found on the head rest but these many have been related to usage. The driver did not sustain any injuries. He was able to exit the vehicle under his own.

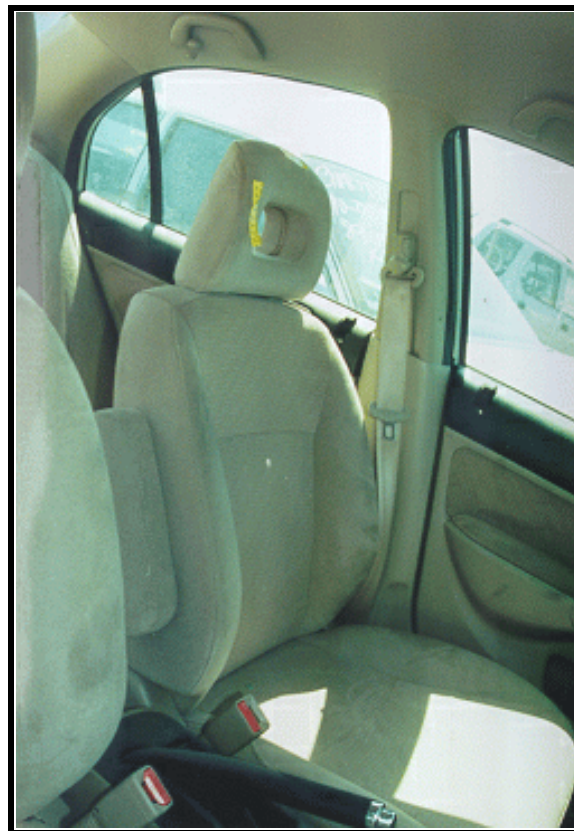


Figure 10. Driver's seated position

Attachment 1. Scene Diagram

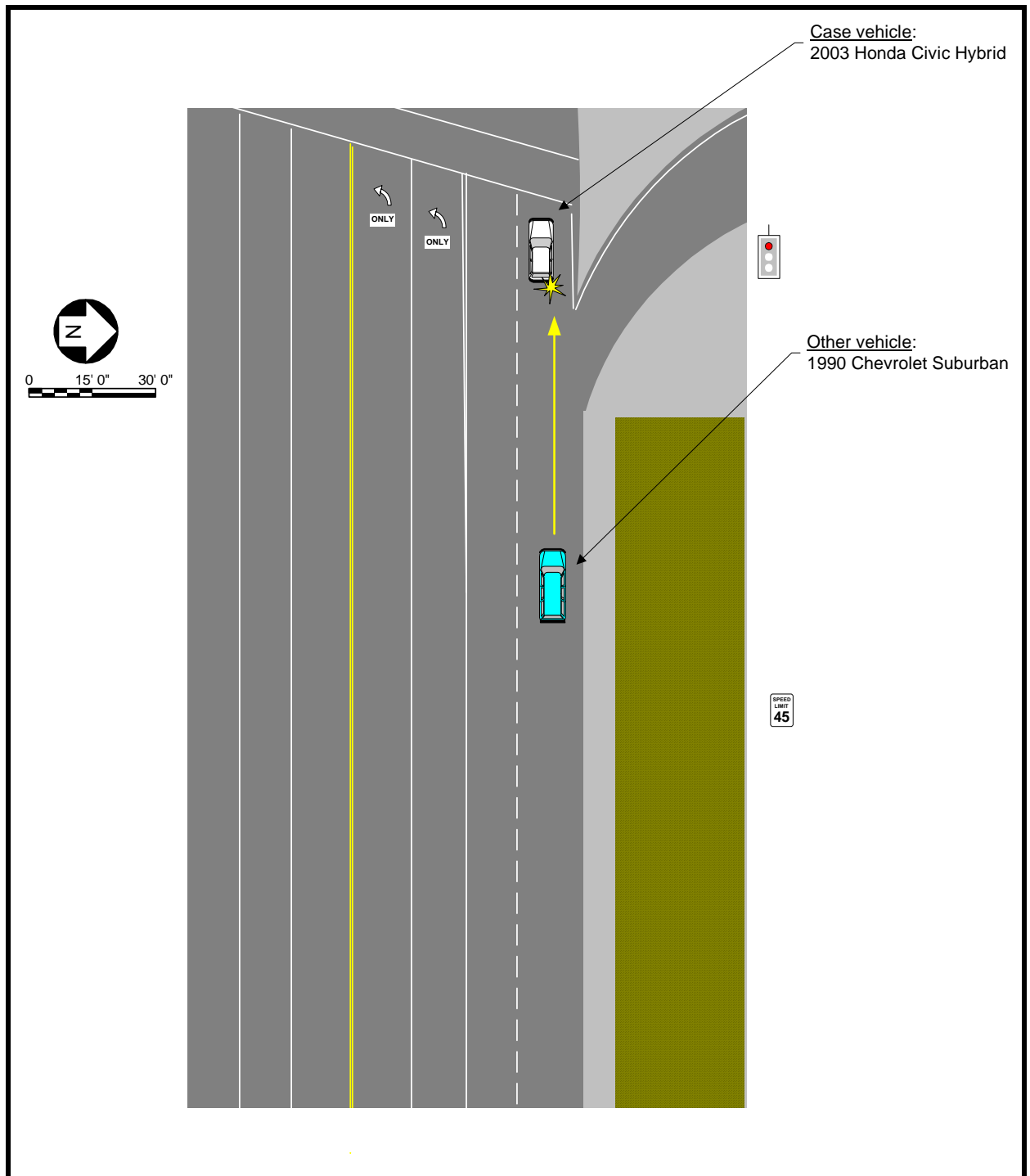


Figure 11. Scene diagram

Attachment 2. Electrical Isolation Test Discussion

This contractor reviewed publicly available manufacturer information regarding the electrical system of the Civic Hybrid to determine likely points to assess vehicle electrical isolation. The system basically consists of the intelligent power unit (IPU) which is located behind the rear seat, the electric motor which is located in the engine compartment, and the motor power cable which is the cable that connects the power unit to the drive unit. The system uses high voltage (144 V) circuits. The high voltage cables and their covers are identified by orange coloring. There are two likely points of electrical exposure: the cable connection to the IPU and the cable connection to the electric motor.

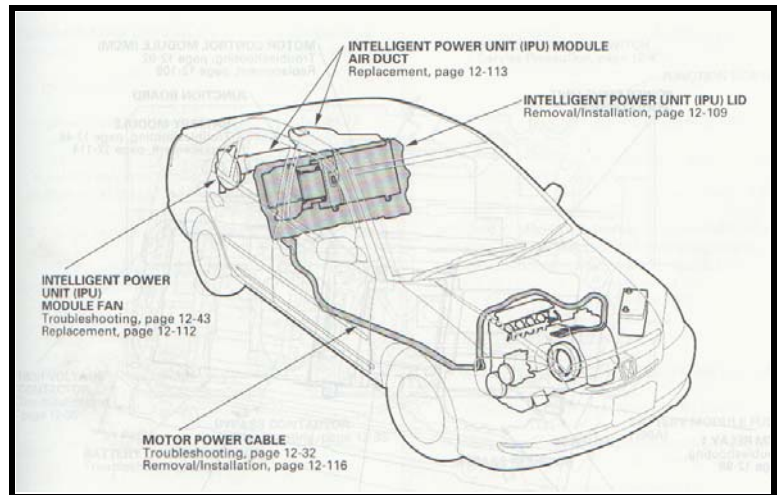


Figure 12. Overview, IMA system

The test for IPU isolation/circuit problems includes the following steps as paraphrased from the Civic Hybrid Service Manual:

- Ignition switch off.
- Remove back seat back.
- Access battery module switch and turn to off.
- Remove IPU lid.
- Measure voltage at the junction board terminals. There should be 30 V or less. If more than 30 V is present, there is a problem in the circuit.

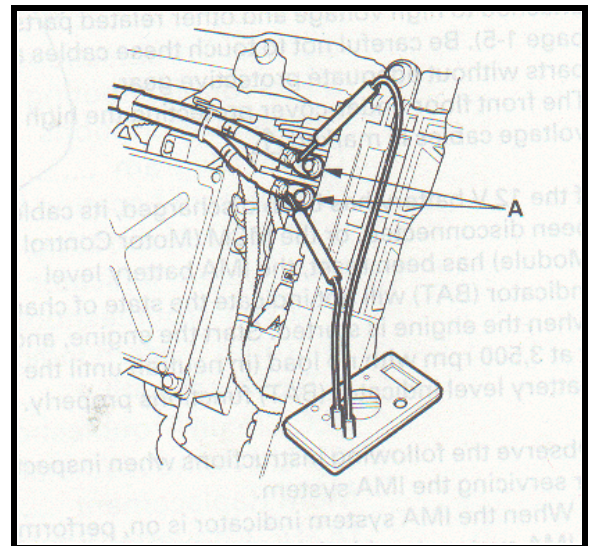


Figure 13. IPU circuit test at battery end of high voltage line

A second test will reveal if there is a short in the high voltage line. This test would involve the following steps:

- Disconnect the high voltage cables from the output terminals on the junction board.
- Measure resistance between high-voltage cables and body ground individually.
- If the resistance is 350 k **S** or lower, there is a short in the high voltage line.

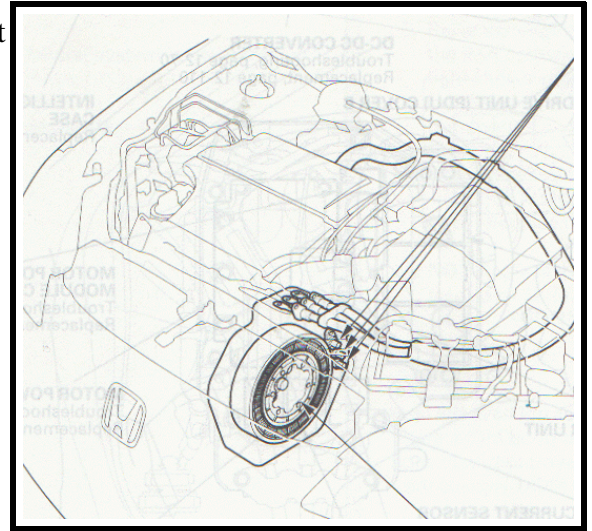


Figure 14. Engine side of high voltage line