

CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE HYBRID VEHICLE CRASH INVESTIGATION

SCI CASE NO.: CA09046

VEHICLE: 2007 HONDA CIVIC HYBRID

LOCATION: NORTH CAROLINA

CRASH DATE: APRIL 2009

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

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 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.

TECHNICAL REPORT STANDARD TITLE PAGE

<p><i>1. Report No.</i> CA09046</p>	<p><i>2. Government Accession No.</i></p>	<p><i>3. Recipient's Catalog No.</i></p>	
<p><i>4. Title and Subtitle</i> Calspan On-Site Hybrid Vehicle Crash Investigation Vehicle: 2007 Honda Civic Hybrid Location: State of North Carolina</p>		<p><i>5. Report Date:</i> November 2009</p>	
		<p><i>6. Performing Organization Code</i></p>	
<p><i>7. Author(s)</i> Crash Data Research Center</p>		<p><i>8. Performing Organization Report No.</i></p>	
<p><i>9. Performing Organization Name and Address</i> Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225</p>		<p><i>10. Work Unit No.</i></p>	
		<p><i>11. Contract or Grant No.</i> DTNH22-07-C-00043</p>	
<p><i>12. Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p><i>13. Type of Report and Period Covered</i> Technical Report Crash Date: April 2009</p>	
		<p><i>14. Sponsoring Agency Code</i></p>	
<p><i>15. Supplementary Note</i> This on-site investigation focused on the Hybrid system in a 2007 Honda Civic Hybrid that was involved in a front-to-rear crash with a 2005 Ford F-150.</p>			
<p><i>16. Abstract</i> This on-site investigation focused on the Hybrid system in a 2007 Honda Civic Hybrid that was involved in a front-to-rear crash with a 2005 Ford F-150. The Honda was equipped with a high-voltage nickel-metal hydride battery pack using potassium hydroxide electrolyte. This battery pack had a total output rating of approximately 158 volts and was used for low speed acceleration and to assist the 1.3-liter gasoline engine in higher speed acceleration. This battery pack was located behind the rear seat of the Honda. This vehicle was equipped with a regenerative braking system to charge the Hybrid battery. In addition to the Hybrid system, the Honda was equipped with a Certified Advanced 208-Complaint (CAC) frontal air bag system, front seat back mounted side impact air bags, and inflatable curtain air bags located in the right and left roof side rails. The manufacturer of the Honda has certified that the vehicle is compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front passenger positions, seat track positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The Honda was struck in the rear while stopped in its traffic lane for a school bus with flashing lights and stop arm activated. The restrained 39-year-old female driver of the Honda sustained a wrist abrasion in this crash and refused medical transport.</p>			
<p><i>17. Key Words</i> Front to Rear Crash, Hybrid Vehicle, Minor Injury</p>		<p><i>18. Distribution Statement</i> General Public</p>	
<p><i>19. Security Classif. (of this report)</i> Unclassified</p>	<p><i>20. Security Classif. (of this page)</i> Unclassified</p>	<p><i>21. No. of Pages</i> 9</p>	<p><i>22. Price</i></p>

TABLE OF CONTENTS

BACKGROUND 1

SUMMARY 2

 CRASH SITE 2

 VEHICLE DATA 2

 2007 HONDA CIVIC HYBRID 2

 2005 FORD F-150 3

 CRASH SEQUENCE 3

 PRE-CRASH 3

 CRASH 3

 POST-CRASH 4

 EXTERIOR DAMAGE 4

 2007 HONDA CIVIC HYBRID 4

 INTERIOR DAMAGE 5

 2007 HONDA CIVIC HYBRID 5

 MANUAL RESTRAINT SYSTEMS 6

 2007 HONDA CIVIC HYBRID 6

 FRONTAL AIR BAG SYSTEM 6

 2007 HONDA CIVIC HYBRID 6

 SIDE IMPACT AIR BAG SYSTEM 6

 2007 HONDA CIVIC HYBRID 6

 HYBRID BATTERY SYSTEM 6

 2007 HONDA CIVIC HYBRID 6

 OCCUPANT DEMOGRAPHICS/DATA 7

 2007 HONDA CIVIC HYBRID 7

 DRIVER INJURIES 8

 DRIVER KINEMATICS 8

CALSPAN ON-SITE HYBRID VEHICLE CRASH INVESTIGATION
SCI CASE NO.: CA09046
VEHICLE: 2007 HONDA CIVIC HYBRID
LOCATION: NORTH CAROLINA
CRASH DATE: APRIL 2009

BACKGROUND

This on-site investigation focused on the Hybrid system in a 2007 Honda Civic Hybrid that was involved in a front-to-rear crash with a 2005 Ford F-150. **Figure 1** is an image of the Honda involved in this case. The Honda was equipped with a high-voltage nickel-metal hydride battery pack using potassium hydroxide electrolyte. This battery pack had a total output rating of approximately 158 volts and was used for low speed acceleration and to assist the 1.3-liter gasoline engine in higher speed acceleration. This battery pack was located behind the rear seat of the Honda. This vehicle was equipped with a regenerative braking system to charge the Hybrid battery. In addition to the Hybrid system, the Honda was equipped with a Certified Advanced 208-Complaint (CAC) frontal air bag system, front seat back mounted side impact air bags, and inflatable curtain air bags located in the right and left roof side rails. The manufacturer of the Honda has certified that the vehicle is compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front passenger positions, seat track positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The Honda was struck in the rear while stopped in its traffic lane for a school bus with flashing lights and stop arm activated. The restrained 39-year-old female driver of the Honda sustained a wrist abrasion in this crash and refused medical transport.



Figure 1. 2007 Honda Civic case vehicle.

The crash was identified through a visit to a regional vehicle salvage facility on July 7, 2009. Based on the severity and location of the damage to the Honda, the case was assigned for an on-site investigation on the same day. The investigation was initiated on July 9, 2009 and involved the inspection and documentation of the Honda, a detailed interview with the owner/driver of the Honda, and the documentation of the crash site. The owner of the Ford refused to allow the inspection of the F-150.

SUMMARY

Crash Site

This crash occurred during the daylight hours of April 2009 in the eastbound lane of a three-lane roadway, inclusive of a center left turn lane. The roadway extended in an east/west direction and was straight and level in the area in which the crash occurred. The roadway was crowned in the center lane with a negative 1.6 percent superelevation extending to both roadsides. An intersecting two-lane roadway extended north from the area of the crash. The conditions at the time of the crash were dry and clear. The traffic lanes were surfaced with asphalt and were 3.6 m (11.8 ft) in width. Both roadsides were bordered by narrow asphalt shoulders, 0.2 m (0.7 ft) in width. On the south roadside were parking lot driveways surfaced in asphalt and grass shoulders. The posted speed limit was 72 km/h (45 mph). The Crash Schematic is included as **Figure 7** of this report.

Vehicle Data

2007 Honda Civic Hybrid

The case vehicle was a 2007 Honda Civic Hybrid four-door sedan. The Honda was manufactured in November 2006 and identified by the Vehicle Identification Number (VIN) JHMFA36297S (production number deleted). The vehicle was purchased new by the current owner/driver in early 2007. The vehicle had been driven approximately 51,488 km (32,000 mi) and was used by the driver primarily for transportation to and from work and recreational activities.

The front-wheel drive Honda was powered by a 1.3-liter transverse mounted four-cylinder gasoline engine linked to a hybrid electric motor and a Continuously Variable Transmission (CVT). The hybrid motor was powered by a 158 volt nickel-metal hydride battery pack. The battery was located behind the rear seat of the vehicle, centered slightly forward of the rear axle. The hybrid battery was concealed by an aluminum cover and a carpeted panel that forms the front of the trunk area. The service brakes were front wheel disc and rear drum with four-wheel anti-lock (ABS). All four windows were closed at the time of the crash. The Honda was equipped with Kumho Powerstar 758 tires on the front and Bridgestone Insignia tires on the rear. All tires were sized at P195/65R15. The vehicle manufacturer recommended tire size was P195/65R15 with 221 kPa (32 PSI) of cold tire pressure for the front and rear tires. The tires were mounted on OEM alloy wheels. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	207 kPa (30 PSI)	6 mm (7/32 in)	None
Left Rear	193 kPa (28 PSI)	6 mm (7/32 in)	None
Right Front	186 kPa (27 PSI)	6 mm (7/32 in)	Longitudinally oriented gouge in tread, no puncture
Right Rear	200 kPa (29 PSI)	6 mm (7/32 in)	None

The interior of the Honda was configured with cloth surfaced five-passenger seating. The front bucket seats were separated by a center console and equipped with adjustable head restraints. The front head restraints were equipped with a whiplash protection system. The left head restraint was adjusted 6 cm (2.4 in) above the full-down position. The right head restraint was in the full-down position at the time of the inspection. The front left seat track was adjusted to a mid-track position 10 cm (3.9 in) forward of full-rear. The front left seat back was deformed rearward to a measured post-crash angle of 48 degrees aft of vertical. The front right seat track was adjusted 7 cm (2.8 in) forward of the full-rear position, with a seat back angle of 33 degrees aft of vertical. The second row seat was a fixed bench with adjustable head restraints. The rear bench was covered by an aftermarket fabric seat cover that included matching fabric covers for all three head restraints. All three head restraints were in the full-down positions.

The interior occupant safety systems consisted of three-point lap and shoulder belts for the five designated seating positions, front retractor and buckle pretensioners, dual-stage (CAC) frontal air bags, front seat back mounted side impact air bags, Inflatable Curtain (IC) air bags that provided protection for the four outboard seating positions, and front seat active head restraints.

2005 Ford F-150

The other vehicle in this crash was a 2005 Ford F-150 extended-cab pickup truck. The Ford was identified by the VIN: 1FTPX12595F (production sequence deleted). The rear-wheel drive F-150 was powered by a 5.4-liter V-8 engine linked to a four-speed automatic transmission. The service brakes were front and rear disc with four-wheel anti-lock (ABS). The owner of the Ford refused to allow inspection of the vehicle or consent to an interview.

Crash Sequence

Pre-crash

Prior to the crash, the 2007 Honda Civic Hybrid and the 2005 Ford F-150 were both traveling eastbound in the right lane of the three-lane roadway. A school bus was traveling westbound on the same roadway and stopped at the intersecting roadway to pick up children. The school bus driver activated the flashing red lights and the front mounted stop arm. The driver of the Honda stopped in her travel lane for the stopped school bus. She stated in the interview that she had come to a complete stop and was stopped in the travel lane for four-to-five seconds prior to the impact. The F-150 was traveling at a police estimated speed of 72 km/h (45 mph) prior to the crash. She did not detect the F-150 and did not initiate avoidance actions prior to the impact.

Crash

The front of the Ford impacted the rear of the Honda in the eastbound travel lane. **Figure 2** depicts the area in which the impact occurred. The directions of force were within the 6 o'clock



Figure 2: Area of impact.

sector for the Honda and 12 o'clock (estimated) for the Ford F-150. The Missing Vehicle algorithm of the WIMSMASH program was used to calculate a total delta-V of 39 km/h (24 mph) for the Honda and 22 km/h (14 mph) for the F-150. The longitudinal and lateral components of the Honda's delta-V were 39 km/h (24 mph) and 0 km/h, respectively. The longitudinal component of the Ford's delta-V was -22 km/h (-14 mph) with a lateral component of 0 km/h. No air bags in the Honda deployed during the rear-end crash event.

The Honda was displaced approximately 45.7 m (150 ft) forward and slightly to the right, coming to rest partially off the roadway to the right on an asphalt surfaced parking lot driveway. The Ford continued its eastbound trajectory evidenced by a 10.5 m (34.5 ft) right front tire mark prior to coming to rest on the roadway 23.7 m (77.8 ft) east of the Point of Impact (POI). Both vehicles traveled past the stopped position of the school bus.

Post-Crash

The driver of the Honda retrieved her cellular phone and placed a call to the 9-1-1 emergency response system. She exited the vehicle under her own power through the driver's door. Police, emergency medical and tow personnel responded to the crash site. The driver stated in the interview that the hybrid battery indicator was still displaying a normal battery charge post-crash, and no instrument panel mounted warning lights related to the hybrid drive system illuminated post-crash. She turned off the ignition as normal operating procedure prior to exiting the vehicle. The driver did not check for any damage to the hybrid battery but was aware that the vehicle was damaged in the area of the battery compartment.

The driver of the Honda refused medical treatment at the scene and was not transported to a medical facility. Both vehicles were towed from the scene due to disabling damage. The Honda remained at a local tow yard before being transferred to a regional salvage facility for auction, where it was inspected. According to the owner of the Ford, the vehicle was repaired and returned to service.

Exterior Damage

2007 Honda Civic Hybrid

The rear of the Honda Civic sustained moderate severity damage to the rear bumper, trunk area and quarter panels of the Honda (**Figure 3**). The combined direct and induced (Field L) damage extended from bumper corner-to-bumper corner and was 112 cm (44.1 in.) in length. The bumper beam, trunk area, spare tire well and both quarter panels were crushed forward. There was a 9 cm (3.5 in) tear in the rear bumper fascia of the Honda located 20-29 cm (7.9-11.4 in) left of the centerline of the vehicle. This tear corresponded in height and width to the left front tow hook of an exemplar 2005 Ford F-150. The left tow hook



Figure 3: Damage to the rear of the Honda.

on the exemplar vehicle was located 34-44 cm (13.4-17.3 in) left of the centerline of the vehicle. The maximum crush was 66 cm (26 in) and was located on the bumper beam 23 cm (9.1 in) left of the vehicle's centerline.

The residual crush profile extended the full width of the damaged bumper beam and was as follows: C1 = 10 cm (3.9 in), C2 = 47 cm (18.5 in), C3 = 65 cm (25.6 in), C4 = 50 cm (19.7 in), C5 = 30 cm (11.8 in), C6 = 21 cm (8.3 in). The longitudinal distance from the maximum crush on the bumper beam to the rear of the hybrid battery compartment was 22 cm (8.7 in). This distance is depicted in **Figure 4**.

The Honda's backlight was disintegrated by the exterior deformation in this rear impact event. All side windows and the windshield were undamaged. The left front, right front and left rear doors remained closed during the crash and were operational post-crash. The right rear door remained closed during the crash and was jammed post-crash. The Collision Deformation Classification (CDC) assigned for this impact was 06-BDEW-6.



Figure 4: Distance remaining between maximum crush and the hybrid battery.

***Interior Damage
2007 Honda Civic Hybrid***

The Honda Civic sustained minor severity interior damage that was attributed to passenger compartment intrusion. The trunk floor displaced the hybrid battery compartment forward into the rear seat back. The intrusion of the Honda is listed on the following table:

Position	Component	Direction	Magnitude
Row 2 Left	Rear seat back	Longitudinal (forward)	4 cm (1.6 in)
Row 2 Left	Front seat back	Longitudinal (rearward)	13 cm (5.1 in)
Row 2 Left	Rear package tray	Vertical	4 cm (1.6 in)
Row 2 Center	Rear seat back	Longitudinal (forward)	3 cm (1.2 in)
Row 2 Center	Rear package tray	Vertical	5 cm (2 in)
Row 2 Right	Rear seat back	Longitudinal (forward)	4 cm (1.6 in)
Row 2 Right	Rear package tray	Vertical	3 cm (1.2 in)

The driver loaded the seat back during the crash, deforming the seat back rearward to a measured angle of 48 degrees. The front left seat back recline mechanism retained the seat back in its post-crash position. Release of the locking mechanism allowed the seat back to move forward; however, the seat back would only lock in the deformed position.

The front seats were equipped with active head restraints that consisted of a mechanical whiplash protection system. This system, activated by a rear impact, would mechanically raise the head restraint and position it forward. Post-crash, the driver's head restraint was

positioned 6 cm (2.4 in) above the full-down position post-crash. The front right head restraint (seat unoccupied) was in the full-down position.

Manual Restraint Systems

2007 Honda Civic Hybrid

The Honda Civic was equipped with manual three-point lap and shoulder belts for the five designated seating positions. All belt systems utilized continuous loop webbing with sliding latch plates. The driver's belt retracted onto an Emergency Locking Retractor (ELR) with a retractor pretensioner. The driver's belt system also utilized a buckle mounted pretensioner. The upper D-ring was adjustable and was set to the full-down position. The driver was using the safety belt at the time of the crash. The pretensioners did not actuate in this rear-end crash.

The front right and all second row safety belt systems utilized switchable ELR/Automatic Locking Retractors (ALR). In addition, the front right belt system utilized both pretensioners. The front right height adjustable D-ring was in the full-down position. These positions were unoccupied at the time of the crash.

Frontal Air Bag System

2007 Honda Civic Hybrid

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, seat track positioning sensors, a front right occupant presence sensor, retractor pretensioners, and safety belt buckle switches. The manufacturer of this vehicle has certified that this Honda is compliant with the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The driver stated that the case vehicle had not been involved in any previous crashes. The driver's air bag was concealed within the center hub of a two-spoke steering wheel. The front right passenger's frontal air bag was concealed within the upper aspect of the front right instrument panel. The CAC frontal air bag system did not deploy in this rear-end crash.

Side Impact Air Bag System

2007 Honda Civic Hybrid

The Honda was equipped with front seat back-mounted side impact air bags and roof side rail mounted inflatable curtain air bags. The side impact air bags did not deploy in this rear-end crash.

Hybrid Battery System

2007 Honda Civic Hybrid

The 2007 Honda Civic was equipped with a hybrid battery system that powered an electric motor that assists, and in some conditions, supplants the gasoline engine. This system improves fuel efficiency while the gasoline engine is in use, or provides power for vehicle movement at lower speeds without use of the gasoline engine.

The battery pack was a Panasonic 158 volt, 5.5 Ah multiple-cell nickel-metal hydride battery. The battery was located behind the rear seat back, vertically mounted and centered slightly forward of the rear axle position. The rear crush to the trunk area resulted in forward displacement of the battery compartment and intrusion of the rear seat back and package tray into the passenger compartment. Due to the resultant damage and intrusion, a limited visual inspection of the battery area was performed. The battery compartment could not be accessed to conduct a voltage test for electrical isolation.

The lower second row seat area, under the seat cushion and the lower aspect of the front of the trunk did not display evidence of leakage from the battery (**Figures 5 and 6**). The area under the vehicle in the vicinity of the battery pack was inspected without visible evidence of leakage. The absence of warning lights and no indication of a reduced charge on the battery meter in the instrument panel pointed toward no damage occurring to the hybrid battery cells.



Figure 5: Area under the hybrid battery and rear seat cushion.



Figure 6: Area under the hybrid battery in the trunk of the Honda.

Occupant Demographics/Data
2007 Honda Civic Hybrid

Driver Age/Sex:	39-year-old/Female
Height:	163 cm (64 in)
Weight:	59 kg (130 lb)
Eyewear:	None
Seat Track Position:	Mid-track
Manual Safety Belt Use:	Lap and shoulder belt
Usage Source:	Vehicle inspection
Egress from vehicle:	Exited the vehicle unassisted through driver's door
Mode of Transport From	
Scene:	None
Type of Medical Treatment:	None

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Left wrist abrasion	Minor (790202.1,2)	Left door panel

Source - Driver Interview

Driver Kinematics

The restrained 39-year-old female driver of the Honda was seated in an upright posture in a mid-track position and was restrained by the manual three-point lap and shoulder belt system. Prior to the crash, the Honda was stopped in the traffic lanes for a stopped school bus. The driver stated that she did not see the Ford approaching the rear of her vehicle; therefore she did not initiate avoidance action or brace prior to impact.

The F-150 impacted the rear of the Honda. The driver initiated a rearward trajectory within the front left seating position. She loaded the left front seat back and displaced the seat back rearward, deforming the recline mechanisms. Her loading force against the seat back actuated the whiplash protection system in the driver's seat. The driver's head restraint moved upward and forward. The driver's head contacted the head restraint which restricted the rearward motion of her head, thus preventing possible neck or cervical spine injury.

During her rearward trajectory, the driver's left hand released from the steering wheel rim and her left wrist area contacted the left door panel. She stated during the interview that the contact displaced her wrist watch that produced an abrasion to the dorsal aspect of her left wrist.

Immediately following the crash, the driver of the Honda turned-off the engine and exited the vehicle without assistance. She refused treatment at the scene and did not seek follow-up treatment at a later time.

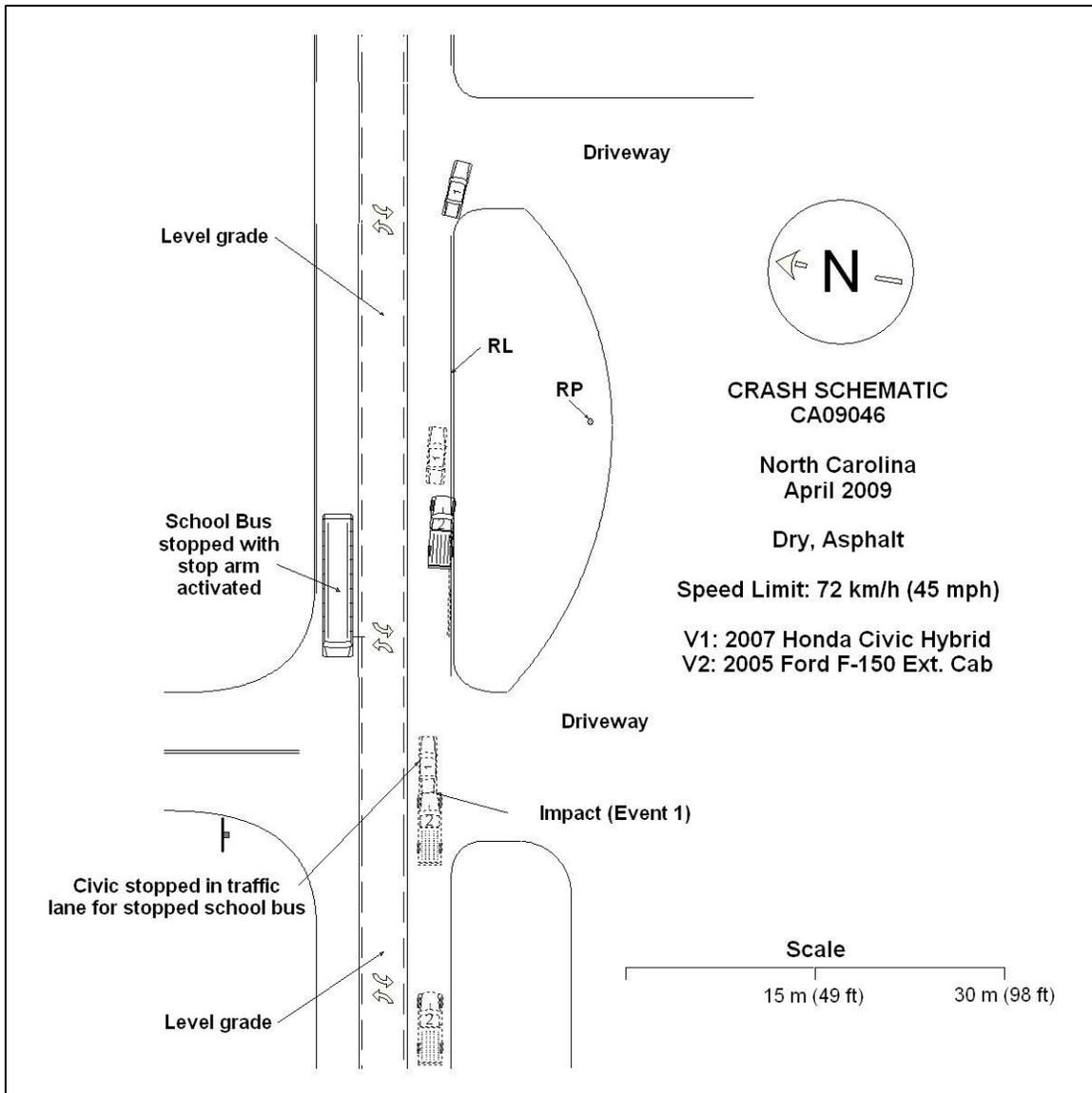


Figure 7: Crash Schematic