CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ALTERNATIVE FUEL VEHICLE CRASH INVESTIGATION

CASE NO.: CA04-036

LOCATION: STATE OF MARYLAND

VEHICLE: 2003 HONDA CIVIC HYBRID

CRASH DATE: AUGUST 2004

Contract No. DTNH22-01-C-17002

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract This on-site investigative effort focused on the performance of the gasoline/electric hybrid fuel system that was present in a 2003 Honda Civic. The hybrid Civic was occupied by a 43-year-old female driver, a 14-year-old male front right passenger, a 14-year-old female rear left passenger, and a 14-year-old male rear right passenger. All of the occupants were restrained by the manual lap and shoulder belts. The driver of the hybrid Civic was operating the vehicle in the outboard lane of a four-lane roadway during daylight hours in heavy traffic conditions. Traffic came to an abrupt stop for a right-turning non-contact vehicle. As the driver of the hybrid Civic stopped her vehicle, it was struck in the back by a 1991 Honda Civic. The front-to-rear impact was slightly offset to the left of the hybrid Civic. The front right passenger was transported by ambulance to a local hospital for evaluation and released. The driver was taken to a local hospital in a private vehicle at a later time the same day for evaluation and released. Both front seat occupants sustained muscle strains. The rear-seat occupants were not injured. The hybrid fuel/battery system was not compromised by the crash.			
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BACKGROUND

This on-site investigative effort focused on the performance of the gasoline/electric hybrid fuel system that was present in a 2003 Honda Civic **(Figure 1)**. The hybrid Civic was occupied by a 43-year-old female driver, a 14-year-old male front right passenger, a 14-year-old female rear left passenger, and a 14-year-old male rear right passenger. All of the occupants were restrained by the manual lap and shoulder belts. The driver of the hybrid Civic was operating the vehicle in the outboard lane of a four-lane roadway during daylight hours in heavy traffic conditions. Traffic came to an abrupt stop for a right-turning non-contact vehicle. As the driver of the hybrid Civic stopped her vehicle, it was struck in the back by a 1991 Honda Civic. The front-to-rear impact was slightly offset to the left of the hybrid Civic. The front right passenger was transported by ambulance to a local hospital for evaluation and released. The driver was taken to a local hospital in a private vehicle at a later time the same day for evaluation and released. Both front seat occupants sustained muscle strains. The rear-seat occupants were not injured. The hybrid fuel/battery system was not compromised by the crash.

Figure 1. Damaged 2003 hybrid Honda Civic

This crash was identified by the driver of the 2003 Honda Civic, who forwarded the notification to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA). The crash information was forwarded to the Calspan Special Crash Investigations team for follow-up. Due to the severity of the damage, the case was assigned for an on-site investigation. Both vehicles were located and cooperation was established with the driver of the 2003 Civic. An on-site investigation was assigned to the Calspan SCI team on August 13, 2004. A Police Accident Report (PAR) was obtained from the investigating agency.

SUMMARY

Vehicle Data - 2003 Honda Civic Hybrid

The 2003 Honda Civic hybrid was identified by the Vehicle Identification Number (VIN): JHMES96603S (production sequence omitted). At the time of the vehicle inspection, the Civic's odometer read 41,423 km (25,740 miles). The vehicle was a four-door sedan that was configured with a 1.3 liter, 4-cylinder gasoline engine and a nickel-metal-hydride (NiMH) battery-powered electric motor. The gasoline engine and electric motor comprise what Honda terms as the Integrated Motor Assist System (IMA™). The specific components of the IMA system will be addressed in the Hybrid Fuel System section later in this report. The Civic was also equipped

with front-wheel-drive, an automatic continuously variable transmission (CVT), front disc/rear drum brakes with ABS, and Electronic Brake Distribution (EBD). The Civic was also configured with rack-and-pinion steering with Electric Power Steering (EPS) and a tilt steering wheel, which was in the full-up position at the time of the vehicle inspection. The Civic was equipped with Dunlop SP 20 FE P185/70R14 OEM tires. The manufacturer's recommended tire pressure was 210 kpa (30 psi). The specific tire data was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	200 kpa (29.0 psi)	6 mm (7/32")	No	None
LR	200 kpa (29.0 psi)	6 mm (8/32")	No	None
RF	197 kpa (28.5 psi)	6 mm (7/32")	No	None
RR	221 kpa (32.0 psi)	6 mm (8/32")	No	None

The seating in the 2003 Civic was configured with front bucket seats with adjustable head restraints and a rear bench seat with integrated outboard head restraints. Both front head restraints were in the full-down position. At the time of the vehicle inspection, the driver's seat track was positioned 17.1 cm (6.8") rear of full-forward and 7.0 cm (2.8") forward of full-rear. The front right seat was found in the full-rear position.

The driver of the hybrid Civic stated that the vehicle was purchased due to environmental considerations and fuel efficiency. There had been no prior service performed on the vehicle, although the "check engine" light was illuminated due to a faulty EGR sensor, which needed to be replaced. The faulty EGR sensor did not affect the performance of the vehicle prior to the crash.

Vehicle Data – 1991 Honda Civic

The 1991 Honda Civic was identified by the VIN: 1HGED3546ML (production sequence omitted). The 1991 Civic was a four-door sedan equipped with a 1.5 liter, 4-cylinder engine, front-wheel-drive, a five-speed manual transmission, power steering, and a tilt steering wheel. The front seating positions were configured with bucket seats and automatic shoulder belts with manual lap belts.

Crash Site

This two-vehicle crash occurred during the daylight hours of August 2004 in the state of Maryland. At the time of the crash, the asphalt roadway was dry and there were no adverse weather conditions. The crash occurred north of a three-leg intersection on a four-lane roadway. The north/south roadway was configured with two travel lanes in each direction that were separated by a painted center left-turn lane. The southbound lanes widened on approach to the intersection to accommodate a right turn lane and were bordered on the outboard aspect by a painted while fog line and a concrete curb. The roadway was straight and level at the crash site. The roadside environment consisted of commercial properties and the posted speed limit was 72 km/h (45 mph). The scene schematic is included as **Figure 14** at the end of this narrative report.

Crash Sequence

Pre-Crash

The 43-year-old female driver of the 2003 hybrid Honda Civic was operating the vehicle in the southbound outboard lane on approach to the three-leg intersection. Traffic volume was heavy and vehicles ahead of the hybrid Civic came to an abrupt stop due to a right-turning non-contact vehicle. The driver brought the hybrid Civic to a controlled stop in the outboard traffic lane **(Figure 2)** behind the stopped non-contact vehicles. The 33-year-old male driver of the 1991 Honda Civic was also operating his vehicle in the outboard southbound lane. He did not detect the stopped traffic in the traffic lane ahead of his vehicle.

Figure 2. Southbound approach for both vehicles

Crash

The front aspect of the 1991 Honda Civic impacted the rear aspect of the 2003 hybrid Civic. The impact was slightly offset to the left. The damage algorithm of the WinSMASH program computed a delta-V of 26 km/h (16.1 mph) for the hybrid Civic and a delta-V of 37 km/h (23 mph) for the 1991 Civic, based on the documented crush profiles. The 1991 Civic's front bumper engaged the rear bumper of the hybrid Civic. As the hybrid Civic's bumper crushed longitudinally, the front of the 1991 Civic underrode the top aspect of the trunk lid. The hybrid Civic was displaced forward approximately 6 m (20') and both vehicles came to rest separated from one another in the southbound travel lane. The driver of the hybrid Civic could not recall if she drove the vehicle to the curb or if it was left in the travel lane.

Post-Crash

The driver of the hybrid Civic used a cellular telephone to call 9-1-1 and instructed the other occupants to remain in the vehicle due to the traffic volume on the roadway and possible injuries. The driver and front right passenger of the hybrid Civic sustained muscle strains. The 14-year-old male front right passenger was removed from the vehicle by rescue personnel and transported by ambulance to a local hospital for evaluation and released. The driver sought evaluation at a local hospital later in the day. The driver of the 1991 Civic sustained minor injuries and was transported by ambulance to a local hospital for treatment.

The driver of the hybrid Civic stated that she thought the vehicle was still running post-crash, and that she turned the engine off with the ignition key. There were no unusual noises or odors associated with the hybrid battery electrical system post-crash. The driver further stated that rescue personnel made no attempts to disconnect any power to the vehicle, and did not appear to recognize the hybrid configuration of the vehicle. The hybrid Civic was removed from the scene on a flatbed truck. The tow operator took the vehicle keys to allow the vehicle to be shifted in to neutral to pull it onto the flat bed, although it was not known if he started the motor to do so.

Vehicle Damage

Exterior Damage – 2003 Hybrid Honda Civic

Figure 3. Rear damage to the 2003 hybrid Civic

The 2003 hybrid Honda Civic sustained moderate rear damage **(Figure 3)** as a result of the impact with the 1991 Civic. The direct damage began on the rear bumper fascia 41 cm (16.0”) right of the centerline and extended 118 cm (46.5”) laterally to the rear left bumper corner. The bumper fascia was partially separated and sustained black transfers from direct contact with the bumper of the 1991 Civic. Minor abrasions were present on the lower edge of the trunk lid from direct contact with the leading edge of the hood of the 1991 Civic. The maximum crush measured 48 cm (18.9”) and was located 2 cm (0.8”) right of the centerline on the bumper beam. The crush displaced the bumper beam and rear wall of the trunk forward, which resulted in the disengagement of the trunk lid from the latch. At the time of the vehicle inspection, the longitudinal distance between the latch on the rear wall of the trunk and the receiver on the trunk lid measured 23 cm (9.0”). The combined direct and induced damage measured 104 cm (41.0”) across the rear bumper beam. The left rear quarter panel was buckled slightly rear of the fuel filler door. It was crushed forward, and the rear aspect deflected downward due to the bumper crush **(Figure 4)**. Due to the slight forward displacement of the left rear quarter panel, the rear aspect of the left rear door overlapped the quarter panel by 1 cm (0.4”). Six crush measurements **(Figure 5)** were documented along the rear bumper beam as follows: C1 = 33 cm (12.9”), C2 = 38 cm (15.1”), C3 = 42 cm (16.6”), C4 = 47 cm (18.4”), C5 = 27 cm (10.6”), C6 = 7 cm (2.6”). The Collision Deformation Classification (CDC) for the impact with the 1991 Civic was 06-BDEW-4.

Figure 4. Lateral view of the crush and damaged left rear quarter panel

Figure 5. View of crush profile along bumper beam and trunk lip

Interior Damage – 2003 Hybrid Honda Civic

Interior damage to the hybrid Civic was minor and attributed to occupant contact. The plastic trim covers around the driver's head restraint posts were displaced due to the loading of the head restraint by the driver. The driver's head restraint was in the full-down position at the time of the vehicle inspection, and was adjusted vertically by the SCI investigator to reveal the plastic covers **(Figure 6)**. The outboard plastic cover was displaced vertically 1 cm (0.4") and the inboard plastic cover was displaced 1 cm (0.4") rearward. The loading to the head restraint did not deform the posts or affect the performance of the vertical adjustment. Neither front seat back sustained damage as a result of the crash, and both front seat recline mechanisms were operational.

Figure 4. Close-up of driver's head restraint and displaced plastic covers

There was no passenger compartment intrusion or additional occupant contact as a result of the crash.

The trunk contained a plastic milk crate, which was crushed between the rear and left side aspects of the trunk. At the time of the vehicle inspection, there were no additional cargo items found in the trunk. The OEM T125/70D15 spare tire was properly mounted in the floor of the trunk. The longitudinal crush deformed the trunk structure, and the rear aspect of the spare tire was deflected slightly upward with the trunk floor. The spare tire remained in position and was not restricted against the forward trunk wall **(Figure 7)**. The driver indicated that a case of bottled water, a bottle of motor oil, and a small knitting bag were present in the trunk at the time of the crash. There was no damage to the items in the trunk, which were removed prior to the SCI vehicle inspection.

Figure 7. View from rear right corner showing the post-crash position of the spare tire

Exterior Damage – 1991 Honda Civic

The 1991 Honda Civic sustained moderate frontal damage as a result of the impact with the hybrid Civic **(Figure 8)**. The maximum crush measured 24 cm (9.3") at the front right corner of the bumper. The direct contact damage began 29 cm (11.8") left of the centerline on the front bumper and extended laterally 99 cm (39.0") to the front right bumper corner. The front bumper was separated at both outboard aspects. Direct contact abrasions extended 17 cm (6.3") longitudinally from the leading edge of the hood on the center aspect. The combined direct and induced damage measured 146 cm (57.5") across the entire front bumper. The hood was buckled rearward. There was no damage to the left front fender; however, the right front fender sustained induced damage from the crash. In addition, prior damage was noted to the right front fender that was not related to this crash **(Figure 9)**. Residue from tape and red paint transfers were present aft of the right headlamp and extended rearward to the right front axle. Six crush measurements were documented across the front bumper beam as follows: C1 = 0.0 cm, C2 = 4 cm (1.8"), C3 = 21 cm (8.3"), C4 = 20 cm (7.9"), C5 = 17 cm (6.6"), C6 = 24 cm (9.3"). The CDC for the frontal impact with the hybrid Civic was 12-FDEW-2.

Figure 8. Damaged 1991 Honda Civic

Figure 9. View of previous damage to the right front fender

Manual Restraints – 2003 Honda Civic Hybrid

The 2003 hybrid Honda Civic was equipped with manual 3-point lap and shoulder belts for each seating position. Each manual restraint was configured with a sliding latch plate. The driver's safety belt **(Figure 10)** was equipped with an Emergency Locking Retractor (ELR) and the remaining safety belts were configured with switchable ELR/Automatic Locking Retractors (ALR). At the time of the vehicle inspection, the driver's adjustable D-ring was in the full-down position and the front right passenger's adjustable D-ring was in the full-up position.

Figure 10. View of driver's safety belt

A plastic after-market safety belt adjuster **(Figure 11)** was present on the driver's lap belt. The specific make/model was not known. The adjuster measured 7 cm (2.6") in width, 4 cm (1.6") in length, and was located near the safety belt's stop button at the time of the vehicle inspection. A lateral 2 cm (0.8") wide clip was present on the top portion, which was designed to receive the shoulder belt in order to re-position the belt on the occupant. A lateral hinged clip was located on the bottom aspect that snapped together on the side opposite the hinge, which was used to secure the adjuster to the vehicle's lap belt webbing. There was no damage to the safety belt adjuster. The driver stated that it was used to re-position the shoulder belt across her shoulder, as the shoulder belt tended to ride against her neck. The adjuster was regularly placed approximately 5 cm (2") away from the latch plate on the lap belt. She further stated that she did not realize that the Civic was equipped with adjustable-height D-rings.

Figure 11. Close-up of after-market safety belt adjuster

The driver's safety belt sustained minor damage from occupant loading. A slight crease from the latch plate was present on the webbing 71 cm (28.0.") above the lower anchor. Some minor ripples were noted on the driver's safety belt webbing that began 65 cm (25.5") above the lower anchor and extended 69 cm (27.3") up the webbing.

The front right passenger's safety belt also exhibited minor cupping in the webbing that began 62 cm (24.5") above the anchor and extended upward 53 cm (21.0"). A crease from the latch plate was present 83 cm (32.5") from the lower anchor.

The rear outboard safety belts did not exhibit any signs of damage. Slight creases from the latch plates were present 56 cm (22.0") and 48 cm (19.0") from the anchors on the left and right safety belts, respectively.

Supplemental Restraint Systems – 2003 Honda Civic Hybrid

The 2003 hybrid Honda Civic was configured with dual-stage frontal air bags and safety belt buckle pretensioners for the driver and front right passenger positions. The frontal air bag system did not deploy and pretensioners did not fire as a result of the crash.

The hybrid Civic was also equipped with front seat back-mounted side impact air bags. The side impact air bags did not deploy as a result of the crash.

Hybrid Fuel System – 2003 Honda Civic

The 2003 hybrid Honda Civic was configured with a gasoline engine and an electric motor. The words "Hybrid" and "Gasoline Electric" were present on the top right aspect of the rear bumper fascia. The 1.3 liter, 4-cylinder gasoline engine and a nickel-metal-hydride (NiMH) battery-powered electric motor comprise what Honda terms as the Integrated Motor Assist System (IMA™). The electric motor was located in the engine compartment between the engine and the

transmission. The NiMH battery module powered the electric motor. According to Honda, the battery module has 120 individual 1.2-volt cells. The battery module is recharged by the electric motor and does not require external charging.

The IPU compartment was located behind the rear seat back over the rear axle. The IPU compartment also housed various controls, electrical components, and cooling fans. The IPU compartment measured 96 cm (37.6”) in width, 37 cm (14.5”) in height, and 18 cm (7.0”) in depth. The compartment was configured with a steel lip that overlapped the opening between the passenger compartment and the trunk. The IPU compartment was secured to the vehicle with four steel brackets that were bolted to the outboard top and bottom aspects of the forward trunk wall.

The IPU compartment was accessed by removing the rear seat back and rear seat cushion **(Figure 12)**. A battery module switch was located behind a steel cover on the center aspect of the IPU compartment lid. A red locking cover was present on the toggle switch. The lid to the IPU compartment was subsequently removed to gain access to the compartment. The battery module was located inside the Intelligent Power Unit (IPU) compartment. The NiMH battery module measured 43 cm (17.0”) in width, 31 cm (12.0”) in height, 15 cm (6.0”) in depth, and was located in the left aspect of the IPU compartment.

Figure 12. View of IPU compartment (rear seat and IPU cover removed)

The IPU compartment did not sustain damage as a result of the crash.

Electricity between the battery module and electric motor was conducted through three heavy-duty, electrically shielded orange cables. The cables were routed longitudinally along the right aspect of the undercarriage and were protected by an orange plastic shield **(Figure 13)**. The cables were further protected by a thermal shield near the exhaust pipe. There was no damage to the electric cables or shields as a result of the crash.

Figure 13. View of undercarriage from front left showing orange electric cables (right side)

Occupant Demographics

Driver

Age/Sex:	43-year-old female
Height:	165 cm (65”)
Weight:	118 kg (260 lb)
Seat Track Position:	17 cm (6.8”) rear of full-forward and 7 cm (2.8”) forward of full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Prescription eyeglasses
Type of Medical Treatment:	Transported by private vehicle later in the day to a local hospital for evaluation and released

Injury	Injury Severity AIS 90 / Update 98	Injury Mechanism
Cervical spine strain	Minor (640278.1,6)	Impact forces
Thoracic spine strain	Minor (640478.1,7)	Impact forces

**Source - Interview*

Driver Kinematics

The 43-year-old female driver was seated in an upright posture and was restrained by the manual 3-point lap and shoulder belt. She was utilizing the after-market shoulder belt adjuster and stated that the shoulder belt was routed through the adjuster, and was positioned over her left shoulder and across the center of her chest. The tilt steering column was adjusted to the full-up position.

At impact, the driver initiated a rearward trajectory. She loaded the seat back with her torso and her head loaded the head restraint. She rebounded forward and loaded the safety belt. The driver came to rest in the driver’s seat as the hybrid Civic came to rest. She sustained muscle strains to her neck and upper back as a result of impact forces, and exited the vehicle under her own power. She was transported by private vehicle to a local hospital later in the same day for evaluation and released.

Front Right Passenger

Age/Sex:	14-year-old male
Height:	170 cm (67”)
Weight:	54 kg (120 lb)
Seat Track Position:	Full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital for evaluation and released

Injury	Injury Severity AIS 90 / Update 98	Injury Mechanism
Cervical spine strain (NFS)	Minor (640278.1,6)	Impact forces
Thoracic spine strain (NFS)	Minor (640478.1,7)	Impact forces

**Source - Interview*

Front Right Passenger Kinematics

The 14-year-old male front right passenger was seated in an upright posture with the seat track adjusted to the full-rear position. He was restrained by the manual 3-point lap and shoulder belt. At impact, he initiated a rearward trajectory. He loaded the seat back with his torso and loaded the head restraint with his head. He rebounded forward and loaded the manual restraint. He sustained muscle strains to his neck and upper back as a result of impact forces and was transported by ambulance to a local hospital for evaluation and released.

Rear Left Passenger

Age/Sex:	14-year-old female
Height:	152 cm (60”)
Weight:	54 kg (120 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Did not sustain injury and was not treated at a medical facility

Rear Left Passenger Kinematics

The 14-year-old female rear left passenger was seated in an upright posture and was restrained by the manual 3-point lap and shoulder belt. At impact, she initiated a rearward trajectory. She loaded the seat back with her torso and loaded the integrated head restraint with her head. She rebounded forward and loaded the safety belt. She did not sustain injury and exited the vehicle under her own power.

Rear Right Passenger

Age/Sex:	14-year-old male
Height:	170 cm (67”)
Weight:	68 kg (150 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Did not sustain injury and was not treated at a medical facility

Rear Right Passenger Kinematics

The 14-year-old male rear right passenger was seated in an upright posture and was restrained by the manual 3-point lap and shoulder belt. At impact, he initiated a rearward trajectory. He loaded the seat back with his torso and loaded the integrated head restraint with his head. He rebounded forward and loaded the manual restraint. He did not sustain injury and exited the vehicle under his own power.

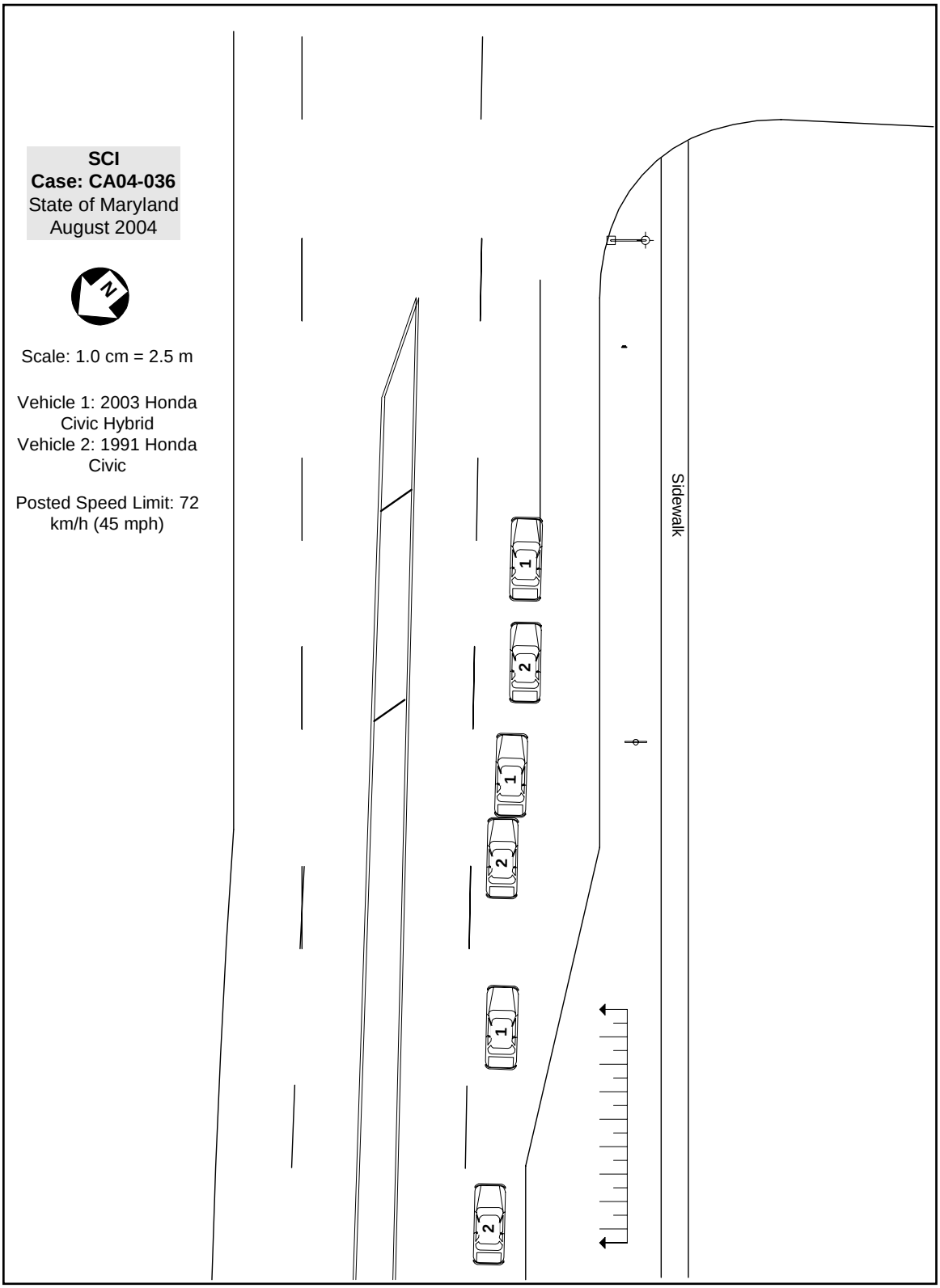

Figure 14. Scene schematic