INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
501 S. Madison Street, Suite 105
Bloomington, Indiana 47403-2452
(812) 855-3908 Fax: (812) 855-3537

ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN09023
LOCATION - NEBRASKA
VEHICLE - 2007 HONDA CIVIC Si
CRASH DATE - May 2009

Submitted:

November 30, 2009

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

DISCLAIMERS

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 crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. *Report No.* IN09023	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Side Impact Inflatable Occupant Protection Investigation Vehicle - 2007 Honda Civic Si Location - Nebraska		5. *Report Date:* November 30, 2009 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 501 South Madison, Suite 105 Bloomington, Indiana 47403-2452		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-07-C-00044	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: May 2009 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site side impact inflatable occupant protection investigation involving a 2007 Honda Si and a 2000 Toyota Celica GT.			
16. *Abstract* This on-site investigation focused on the side impact air bag system of a 2007 Honda Civic Si and the sources of the injuries sustained by the driver and front passenger. The crash involved the Honda and a 2000 Toyota Celica GT. The Honda was occupied by a restrained 19-year-old male driver and a restrained 19-year-old male front passenger. The driver was traveling south in the outside through lane of a divided city street approaching a 4-leg intersection. The Toyota was occupied by an 18-year-old male driver who was traveling west on a 2-lane city street. He was delivering food and intended to continue west through the intersection into an apartment complex. The front plane of the Toyota impacted the left side plane of the Honda. The direction of force on the Honda was within the 11 o'clock sector and the impact force was sufficient to trigger the deployment of the driver's seat-mounted side impact air bag and the left side impact inflatable curtain (IC) air bag. The front passenger's seat-mounted side impact air bag and the right IC air bag also deployed. The driver of the Honda sustained moderate injury due to loading the safety belt, while the front passenger sustained minor injury due to impact forces. The driver and front passenger were transported by private vehicle to a hospital and treated in the emergency room and released.			
17. *Key Words* Side Impact Air Bag Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 10	22. *Price*

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

IN09023

Page No.

This on-site investigation focused on the side impact air bag system of a 2007 Honda Civic Si (**Figure 1**) and the sources of the injuries sustained by the driver and front passenger. The Honda was equipped with front seat-mounted side impact air bags and side impact inflatable curtain (IC) air bags. This crash was brought to our attention on June 26, 2009 by the National Highway Traffic Safety Administration (NHTSA) through the sampling activities of the National Automotive Sampling System-General Estimates System (NASS-GES). This investigation was assigned on July 20, 2009. The crash involved the Honda and a 2000 Toyota Celica GT. The crash occurred in May, 2009, at 1729 hours, in Nebraska and was investigated by the city police department. The Honda was inspected and the driver was interviewed on July 21, 2009. The crash scene inspection and a partial inspection of the Toyota were conducted on July 22, 2009. This report is based on the police crash report, scene and vehicle inspections, driver interview, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2007 Honda Civic Si

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Honda was traveling was a 5-lane, divided, city street, traversing in a north-south direction. The Honda was traveling south approaching a 4-leg intersection. On the northern leg of the intersection, both the north and south roadways had 2 through lanes while the southbound roadway had a left turn lane. Each lane was approximately 3.8 m (12.5 ft) in width. The trafficway was divided by a raised concrete median that was 1.4 m (4.6 ft) in width near the intersection. Roadway pavement markings consisted of broken white lane lines and a solid white left turn lane line. The intersection was uncontrolled for north-south traffic. The trafficway on which the Toyota was traveling was a 2-lane, undivided, city street, traversing in an east-west direction. The Toyota was traveling west approaching the intersection. On the eastern leg of the intersection, the roadway had one through lane in each direction and was controlled by a stop sign. There were no pavement markings and the roadway was 7.4 m (24.3 ft) in width. The posted speed limit was 64 km/h (40 mph) for the Honda and 48 km/h (30 mph) for the Toyota. At the time of the crash, the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was wet concrete. The Honda's roadway had a negative 2.5% grade and the Toyota's roadway was level. The traffic density was heavy and the site of the crash was urban residential. The Crash Diagram can be seen on page 10 of this report.

Pre-Crash: The Honda was occupied by a restrained 19-year-old male driver and a restrained 19-year-old male front passenger. The driver was traveling south (**Figure 2**) in the outside through lane and intended to continue south through the intersection. The Toyota was occupied by an 18-

year-old male driver who was traveling west (**Figure 3**). He was delivering food and intended to continue west through the intersection into an apartment complex. The driver of the Honda took no avoidance actions. The crash occurred in the outside southbound lane within the intersection.

Crash: The front plane of the Toyota (**Figure 4**) impacted the left side plane of the Honda (**Figure 5**). The direction of force on the Honda was within the 11 o'clock sector and the impact force was sufficient to trigger the deployment of the driver's seat-mounted side impact air bag and the left IC air bag. The front passenger's seat-mounted side impact air bag and the right IC air bag also deployed. The impact caused the Honda to rotate clockwise and the right side wheels departed the west side of the roadway. The vehicle reentered the southbound lanes and traveled southeast across the trafficway where it came to final rest on the east side of the northbound lanes heading southeast. As a result of the impact, the Toyota rotated counterclockwise and came to final rest in the intersection heading southwest.

Figure 2: Approach of the Honda to the intersection; arrow shows approach of the Toyota

Figure 3: Approach of the Toyota; arrow shows the approach of the Honda

Figure 4: Damage on the front plane of the Toyota from the impact with the left side plane of the Honda

Figure 5: Damage on the left side lane of the Honda from the impact with the Toyota

Post-Crash: The police responded to the crash scene. No emergency medical or rescue services responded to the crash scene. The driver and front passenger of the Honda remained at the crash

scene until the Honda was towed away. They were transported by private vehicle from the crash scene to a hospital. The Toyota was also towed from the crash scene due to damage. The driver of the Toyota was not injured.

CASE VEHICLE

The 2007 Honda Si was a front wheel drive, 2-door coupe (VIN: 2HGFG21547H------), equipped with a 2.0-liter, 4-cylinder engine, 5-speed manual transmission, and 4-wheel anti-lock brakes. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts, dual stage driver and front passenger frontal air bags, seat-mounted side impact air bags, and side impact IC air bags that provided protection to the front and second row outboard seat positions. The second row was equipped with a bench seat with folding backs, adjustable head restraints, lap-and-shoulder safety belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The vehicle's mileage was 12,325 miles (19,835 kilometers) and the specified wheelbase was 265 cm (104.3 in).

CASE VEHICLE DAMAGE

Exterior Damage: The impact with the Toyota involved the left side plane of the Honda. The left fender, left front door and quarter panel were directly damaged. The direct damage began 36 cm (14.2 in) forward of the left rear axle and extended 291 cm (114.6 in) forward along the left side. The crush measurements were taken at the mid-door level and the residual maximum crush was 10 cm (3.9 in) occurring at both C_4 and C_5 (**Figure 6**). The height of the vehicle's sill was 28 cm (11 in). The height of the maximum door crush was 49 cm (19.3 in) and the Door Sill Differential was 10 cm (3.9 in). The left side wheelbase was shortened 3 cm (1.2 in), while the right side wheelbase was extended 2 cm (0.8 in). The induced damage involved the front bumper fascia, left fender, and left quarter panel. The table below shows the left side crush profile.

Figure 6: Top view of the crush on the left side plane of the Honda

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	291	10	305	0	2	8	10	10	0	49	43
in		114.6	3.9	120.1	0.0	0.8	3.2	3.9	3.9	0.0	19.3	16.9

Damage Classification: The Collision Deformation Classification (CDC) was **11-LYEW-1** (**340** degrees) for the left side impact. The Missing Vehicle algorithm of the WinSMASH program calculated the vehicle's total Delta V as 16 km/h (10 mph). The longitudinal and lateral velocity changes were -15.0 km/h (-9.0 mph) and 5.4 km/h (3.4 mph), respectively. The results were based only on the Honda's crush profile and should be considered as a borderline reconstruction of the Delta V.

The vehicle manufacturer's recommended tire size was P215/45R17. The Honda was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	193	28	221	32	5	6	Sidewall abraded	No	No
LR	Flat	Flat	221	32	6	8	None	No	Yes
RR	221	32	221	32	6	8	None	No	No
RF	Flat	Flat	221	32	5	6	None	No	Yes

Vehicle Interior: The inspection of the Honda's interior (**Figure 7**) revealed a possible occupant contact abrasion on the left front door armrest. No other discernable evidence of occupant contact was observed. There was no damage to the steering wheel and no compression of the energy absorbing steering column.

Figure 7: The driver's seating area

The left front door was jammed shut while the right front door remained closed an operational. The pre-crash status of the left front door window glazing was open and the glazing was cracked and in place. The left front glazing was tempered, but the after market tinting material prevented the glazing from disintegrating during the crash. The pre-crash status of the remaining glazings was either fixed or closed and they were undamaged. The rear upper quadrant of the left front door intruded laterally 4 cm (1.6 in). There were no other intrusions.

AUTOMATIC RESTRAINT SYSTEM

The Honda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that was certified by the manufacturer to be compliant to the Advanced Air Bag portion

of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bag system consisted of dual stage driver and front passenger air bags, driver seat position sensor, seat belt buckle switch sensors, retractor and seat belt buckle-mounted pretensioners, and a front right passenger weight sensor. Neither the driver nor front passenger frontal air bags deployed in this crash.

The Honda's side impact air bag system consisted of front seat-mounted side impact air bags and roof side rail-mounted IC curtain air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the vehicle's side impact sensors were located within the lower B and C-pillars. The inflators for the IC air bags were located within the C-pillars.

The driver's seat-mounted side impact air bag was located within the outboard side of the seat back (**Figure 8**) and deployed through a tear-seam. The air bag (**Figure 9**) was designed with one 3 cm (1.2 in) vent port located on the outboard side. The air bag had a single oval tether where both sides of the air bag were sewn together. The sewn area was 15 cm (5.9 in) in width and 9 cm (3.5 in) in height. The deployed air bag was 50 cm (19.7 in) in height and 36 cm (14.2 in) in width at its widest point. Inspection of the air bag revealed no discernable evidence of occupant contact and no damage. The front right seat-mounted side impact air bag was of the same construction and dimensions. It was not damaged and there was no discernable evidence of occupant contact.

Figure 8: The location of the front left seat-mounted side impact air bag

Figure 9: The deployed left front seat back-mounted side impact air bag

The left IC air bag was located along the roof side rail (**Figures 10**) inside the headliner and extended from the A-pillar to the C-pillar. The deployed IC air bag was 141 cm (55.5 in) in width, 35 cm (13.8 in) in height, and extended 8 cm (3.1 in) below the beltline. It was attached at the A-pillar by a cloth tether 27 cm (10.6 in) in length. The gap between the air bag and the A-pillar at the beltline was 39 cm (15.3 in). There was no visible tether at the C-pillar. There was what appeared to be a single vent port on the front edge of the air bag. The fold creases on the air bag indicated that it had been folded accordion fashion within the headliner. Inspection of

the air bag revealed no damage and no discernable evidence of occupant contact. The right IC air bag was of the same construction and dimensions. It was not damaged and there was no discernable evidence of occupant contact.

Figure 10: The deployed left IC air bag

MANUAL RESTRAINT SYSTEM

The Honda was equipped with lap-and-shoulder safety belts for the front and second row seating positions. The driver's seat belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and a fixed upper anchor. The front passenger safety belt consisted of continuous loop belt webbing, an ELR/Automatic Locking Retractor (ALR), sliding latch plate, and fixed upper anchor. Both front row safety belts were equipped with buckle-mounted and retractor-mounted pretensioners, which actuated during the crash. The second row safety belts were similar to the front passenger safety belt, but were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed a load impression from the latch plate belt guide on the seat belt webbing located 14 cm (5.5 in) above the stop button. The buckle-mounted pretensioner was reduced 4 cm (1.6 in) in length. The retractor was also jammed with a length of belt webbing extended out of the retractor consistent with usage of the safety belt. This evidence indicated that the driver was restrained at the time of the crash.

Inspection of the front right passenger's safety belt assembly revealed a load abrasion on the belt webbing located 18 cm (7.1 in) above the stop button. The buckle-mounted pretensioner was reduced 5 cm (2 in) in length. The retractor was also jammed with a length of belt webbing extended out of the retractor consistent with usage of the safety belt. This evidence indicated that the front passenger was restrained at the time of the crash.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the driver of the Honda [19-year-old, male; 178 cm (70 in) and 64 kg (140 lbs)] was seated in an upright posture with his back against the seat back. He had his right foot on the accelerator, left hand on the steering wheel, and right hand on the gear shift lever. The seat track was adjusted between the middle and full-rear positions and the seat back was slightly reclined. The adjustable head restraint was located in the full-down position, and the distance from the top of the seat back to the top of the head restraint was 20 cm (7.9 in). The tilt steering column was located between the center and full-down positions. The driver was not wearing glasses or contact lenses at the time of the crash.

The Honda's left side impact with the front of the Toyota displaced the driver forward and left opposite the 11 o'clock direction of force and he loaded the safety belt. While there was no discernable evidence of occupant contact on the left seat-mounted side impact air bag or IC air

bag, the left side of the driver's torso probably loaded the seat-mounted side impact air bag and his head probably loaded the IC air bag. The driver sustained a non-anatomic brain injury, a neck strain, and a left ear injury that were probably due to loading the left IC air bag. The driver reported ringing in the ear that has continued since the crash. The driver also sustained a strain of the lower back with disk height loss at the 9th and 10th thoracic vertebrae that were possibly related to loading the safety belt.

CASE VEHICLE DRIVER INJURIES

The driver was transported from the crash scene to a hospital by private vehicle. He was treated in the emergency room and released. He has visited his private physician twice regarding the ringing in his ear and the back injury. He also missed 5 work days as a result of the crash. The table below shows the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with dizziness; GCS=15	minor 160402.1,0	Air bag, driver's side inflatable curtain	Probable	Emergency room records
2	Strain, acute cervical, with hypomobility of cervical spine	minor 640278.1,6	Air bag, driver's side inflatable curtain	Probable	Emergency room records
3	Injury left ear [i.e.,Tinnitus (ringing in the ear[1])], not further specified	minor 240299.1,2	Air bag, driver's side inflatable curtain	Probable	Interviewee (same person)
4 5	Strain lower thoracic spine with disk height loss T_9-T_{10} and Schmorl's node[2] at inferior end plate of T_9	minor 640478.1,7 650499.2,7	Lap portion of safety belt system (indirect injury)	Possible	Emergency room records

CASE VEHICLE FRONT ROW PASSENGER KINEMATICS

The front row passenger [19-year-old, male 180 cm (71 in) and 77 kg (170 lbs)] was seated in an upright posture with his back against the seat back, left hand on his lap, and right arm on the door armrest. The seat track was adjusted to the rear position and the seat back was slightly reclined. The adjustable head restraint was located in the full-down position, and the distance

---

[1] According to the website, http://www.webmd.com/, one possible cause of tinnitus is: injuries, such as whiplash or a direct blow to the ear or head.

[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
node (nood) **[L. nodus knot]**: a small mass of tissue in the form of a swelling, knot, or protuberance, either normal or pathological.
Schmorl node: an irregular or hemispherical bone defect in the upper or lower margin of the body of the vertebra.

from the top of the seat back to the top of the head restraint was 20 cm (7.9 in). The passenger was not wearing glasses or contact lenses at the time of the crash.

The left side impact on the Honda displaced the front row passenger forward and left opposite the 11 o'clock direction of force and he loaded the safety belt. The passenger sustained a neck strain due to impact force and a contusion on the chest from loading the safety belt. He also sustained an abrasion on the right arm, probably due to loading the right seat-mounted side impact air bag.

CASE VEHICLE FRONT ROW RIGHT PASSENGER INJURIES

The front row passenger was transported from the crash scene to a hospital by private vehicle. He was treated in the emergency room and released. The passenger missed no work days as a result of the crash. The table below shows the passenger's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Strain, acute cervical, not further specified	minor 640278.1,6	Noncontact injury: impact forces	Probable	Emergency room records
2	Contusion chest wall over ribs, not further specified	minor 490402.1,9	Torso portion of safety belt system	Probable	Emergency room records
3	Abrasions right arm, not further specified	minor 790202.1,1	Air bag, front right passenger's side impact	Probable	Emergency room records

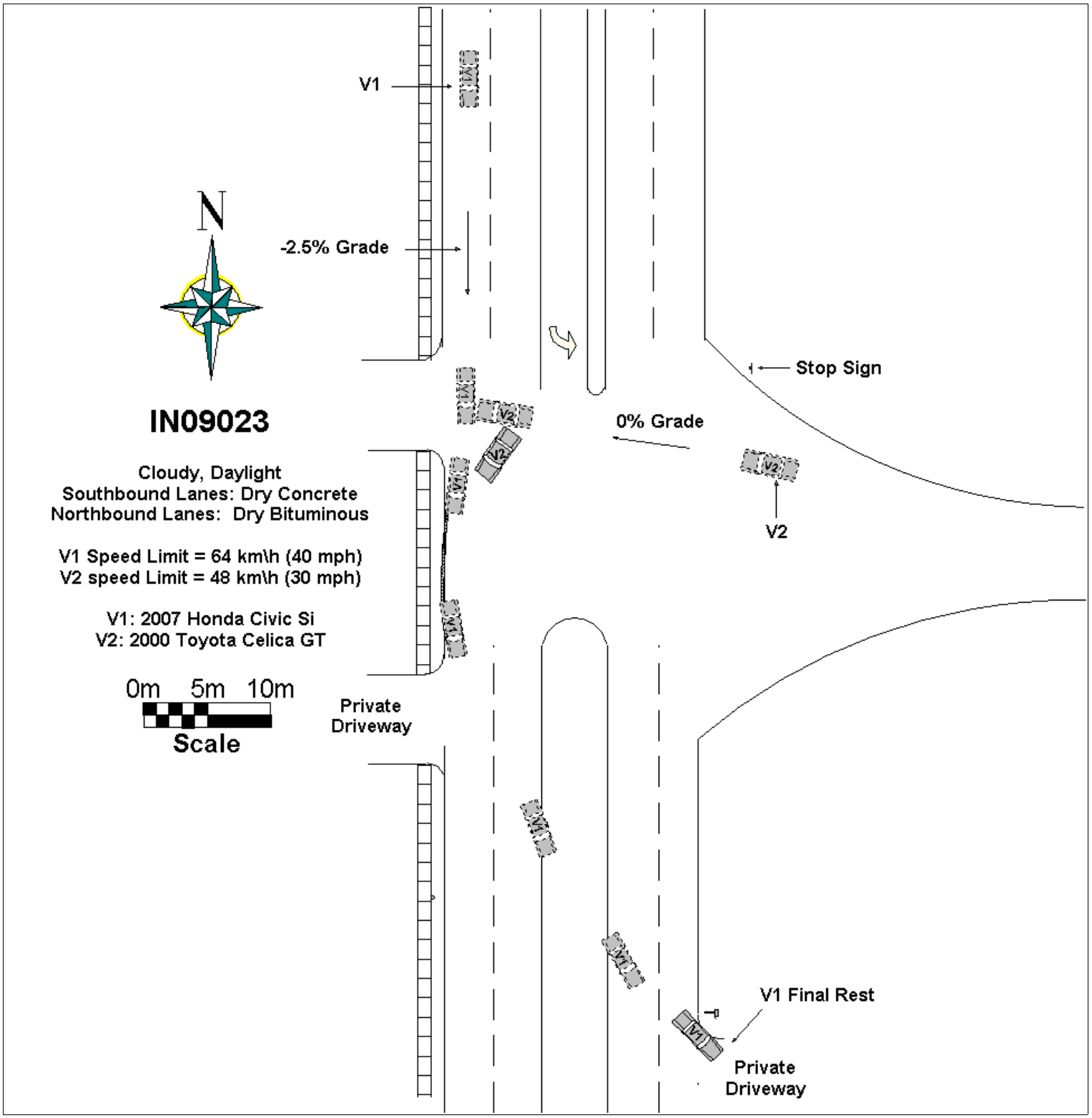
OTHER VEHICLE

The 2000 Toyota Celica GT was a front wheel drive, 2-door, hatchback (VIN: JTDDR32T4Y0-------) manufactured in April 2000. It was equipped with a 1.8-liter, 4-cylinder engine, and driver and front passenger redesigned frontal air bags.

Exterior Damage: The impact with the Honda involved the Toyota's front plane. The direct damage began at the front right bumper corner and extended across the full width of the bumper. The vehicle was located in a garage at the owner's residence and due to the circumstances of the inspection, the damage was documented with photographs only.

Damage Classification: The CDC for the front impact with the Honda was **02-FDEW-2** (**60 degrees**). The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta V as 20 km/h (12.4 mph). The longitudinal and lateral velocity changes were –10.0 km/h (-6.2 mph) and -17.3 km/h (10.8 mph), respectively. The results were based only on the Honda's crush profile and should be considered as a borderline reconstruction of the Toyota's Delta V.

Other Vehicle's Driver: The police crash report indicated that the Toyota's driver (18-year-old, male) was restrained by the lap-and-shoulder safety belt and his frontal air bag deployed. The driver sustained no police reported injury and was not transported to a hospital.


V1
N
-2.5% Grade
Stop Sign
IN09023
0% Grade
Cloudy, Daylight
Southbound Lanes: Dry Concrete
Northbound Lanes: Dry Bituminous
V1 Speed Limit = 64 km\h (40 mph)
V2 speed Limit = 48 km\h (30 mph)
V1: 2007 Honda Civic Si
V2: 2000 Toyota Celica GT
V2
0m 5m 10m
Scale
Private
Driveway
V1 Final Rest
Private
Driveway