INDIANA UNIVERSITY

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

ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN10025
LOCATION - MISSOURI
VEHICLE - 2008 HONDA CIVIC
CRASH DATE - May 2010

Submitted:

December 30, 2010

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.* IN10025	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Rollover Investigation Vehicle - 2008 Honda Civic Location - Missouri		5. *Report Date:* December 30, 2010 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 Street, 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 2010 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site rollover investigation involving a 2008 Honda Civic EX			

16. *Abstract*

This on-site investigation focused on the rollover of a 2008 Honda Civic EX. The Honda was occupied by a restrained 19-year-old female driver and a restrained 19-year-old female front right passenger. The vehicle was traveling north on a U.S. highway in the first lane from the right. The driver became distracted while looking for an object in the center console and the vehicle departed the east road edge The driver initiated a left steering maneuver and the vehicle traveled back across the roadway and off the west road edge. The driver initiated a right steering maneuver and the vehicle traveled off the east road edge, rotating clockwise. The Honda traveled into a ditch and the left quarter panel impacted a sign post (event 1). The vehicle traveled up the back slope of the ditch and rolled over, left side leading (event 2) four quarter turns. The vehicle returned to its wheels and the front plane impacted a barbed wire fence and penetrated through the fence (event 3). The Honda came to final rest upright, heading east. The Honda was equipped with front seat-mounted side impact air bags and side impact inflatable curtain (IC) air bags, both of which deployed during the rollover. The driver and front row right passenger were transported by ground and air ambulance, respectively, to local medical facilities. Both occupants were treated in the emergency room and released. The driver sustained minor injuries, while the front right passenger sustained a moderate injury. The Honda was towed from the crash scene due to damage.

17. *Key Words* Rollover	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* 9	22. *Price*

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

TABLE OF CONTENTS IN10025

Page No.

The focus of this on-site investigation was the 2008 Honda Civic EX, which rolled over after departing the roadway. This crash was brought to the National Highway Traffic Safety Administration's (NHTSA) attention on June 22, 2010 by the Transportation Research Center at Indiana University. This investigation was assigned on July 12, 2010. The crash involved only the Honda (**Figure 1**). The crash occurred in May, 2010, at 0940 hours, in Missouri and was investigated by the Missouri State Highway Patrol. The crash scene was inspected on July 19, 2010 and the Honda on July 20, 2010. The occupant interview was completed on July 26, 2010. This report is based on the police crash report, vehicle inspection, crash scene inspection, inspection of an exemplar vehicle, front right passenger interview, occupant kinematic principles, and evaluation of the evidence.

Figure 1: Damaged 2008 Honda Civic EX

CRASH CIRCUMSTANCES

Crash Environment: This crash occurred during daylight hours and clear weather conditions on a 4-lane, divided U.S. highway. The trafficway traversed in a north-south direction. The roadway that the Honda was traveling on had 2 through lanes. Each travel lane was approximately 3.9 m (12.8 ft) in width. The roadway pavement markings consisted of broken white lane lines, a solid white outside edge line, and a solid yellow median edge line. The roadway surface was dry, level, bituminous . The speed limit was 113 km/h (70 mph). The site of the crash was rural. The Crash Diagram is on page 9 of this report.

Pre-Crash: The Honda was occupied by a restrained 19-year-old female driver and a 19-year-old female front right passenger. The Honda was traveling north in the outside lane on a level grade. Based on the SCI interview with the front right passenger, both she and the driver became distracted while looking for an object in the center console and the driver was not focusing on the roadway. The vehicle traveled off the east side of the roadway and onto a low gravel shoulder. According to a witness, the Honda returned to the roadway, traveled across both lanes, and slightly onto the left roadside. The driver steered back onto the roadway, then traveled off the east side of the roadway, rotating clockwise. According to the interviewee, the driver never disengaged the cruise control. The crash occurred on the east roadside.

Figure 2: Roadway departure, 15 m (49 ft) from sign post impact

Crash: The Honda traveled onto the right roadsideand was in a clockwise yaw as it traveled into a ditch, negatively sloped at 18% (**Figure 2**). The left quarter panel impacted a metal sign post (event 1) and the Honda continued up the back slope of the ditch, positively sloped at 30%. This caused the vehicle to trip and roll over (event 2), left side leading, four quarter turns. The Honda returned to its wheels and the front plane impacted a barbed wire fence (event 3). As the vehicle continued, the fence impacted the right A-pillar and roof and right door. During the crash sequence, both side impact inflatable curtain (IC) air bags deployed as well as both front seat-mounted side impact air bags.

Post-Crash: The driver and front right passenger exited the vehicle, unassisted through the right front door. Police and rescue personnel were notified at 0948 hours and arrived on the scene at 0954 hours. The driver was transported by ambulance to a local hospital. The passenger was transported via helicopter to a level 3 trauma center. The vehicle was towed from the crash scene due to damage.

CASE VEHICLE

The 2008 Honda Civic EX was a front wheel drive, 2-door coupe (VIN: 2HGFG12868H------) equipped with a 1.8L, I-4 gasoline engine and a 5 speed automatic transmission. The vehicle was also equipped with driver and front right passenger dual stage frontal air bags, side impact IC air bags, and front seat-mounted side impact air bags. The front row was equipped with bucket seats, adjustable head restraints, and lap-and-shoulder safety belts. The second row was equipped with a bench seat, lap-and-shoulder safety belts, adjustable head restraints, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions.

CASE VEHICLE DAMAGE

Exterior Damage Event 1: The Honda sustained left side plane damage during the impact with the sign post (**Figure 3**). The direct damage was limited to the left quarter panel. It began 276 cm (108.7 in) rear of the left front axle and extended rearward 3 cm (1.2 in). The maximum residual crush was 8 cm (3.1 in) occurring at C_2. The table below presents the vehicle's left side plane crush profile.

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	3	8	55	4	8	6	4	2	2	-145	-135
in		1.2	3.2	21.7	1.6	3.2	2.4	1.6	0.8	0.8	-57.1	-53.2

Damage Classification Event 1: The Collision Deformation Classification (CDC) for the sign post impact was 08LBEN1 (230 degrees). The Barrier algorithm of the WinSMASH program was used to calculate a Barrier Equivalent Speed (BES) of 5.9 km/h (3.7 mph). A Delta V could not be calculated since impacts with yielding objects are out of scope for the program.

Exterior Damage Event 2: The Honda sustained damage on the both side planes and the top plane during the rollover (event 2). The direct damage on the left side plane began 39 cm (15.4 in) forward of the left front axle and extended 353 cm (138.9 in) rearward along the left fender, A-pillar, door, and quarter panel (**Figure 3**). The direct damage on the right side plane began 57 cm (22.4 in) forward of the right front axle and extended 350 cm (137.8 in) rearward along the right fender, A-pillar, door, and quarter panel. The direct damage on the top of the Honda began on the roof at the windshield header and extended 55 cm (21.6 in) along the roof rail, tapering off to the left side of the vehicle (**Figure 4**). The maximum width of the direct damage was 108 cm (42.5 in). The maximum lateral crush was located at the right roof side rail (**Figure 5**), 90 cm (35.4 in) forward of the right rear axle and measured 3.5 cm (1.4 in). The maximum vertical crush was located at the right rear roof area (**Figure 6**), 64 cm (25.1 in) forward of the right rear axle, and measured 13 cm (5.1 in). The left and right side wheelbases were extended 1 cm (0.4 in) but there was no other induced damage. Based on the amount of crush to the roof, the severity of the rollover damage was moderate.

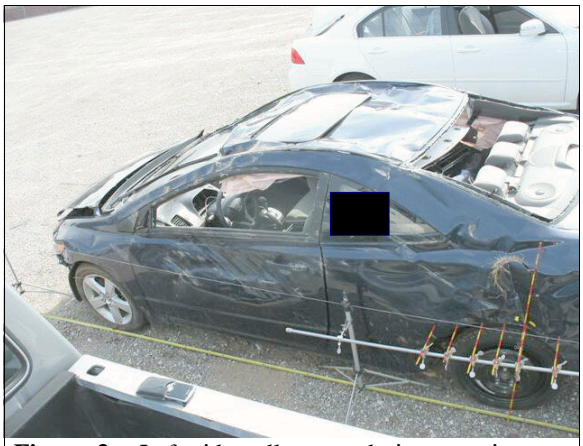


Figure 3: Left side rollover and sign post impact damage

Figure 4: Rollover damage to roof

Figure 5: Lateral max crush to right roof rail

Damage Classification Event 2: The CDC for the rollover was 00TYDO2. The WinSMASH program could not be used to calculate the Delta V for this event since rollovers are out of scope for the program. Based on the extent of the roof crush, the severity of the rollover damage was minor.

Exterior Damage Event 3: The fence impact involved the front, right, and top planes. Direct damage initiated on the bumper fascia and resumed 60 cm (23.6 in) rear of the right front axle extending 200 cm (78.7 in) rearward on the right A-pillar, right door, roof, and roof side rail. The damage from the fence consisted of scratches.

Damage Classification Event 3: The fence impact was a penetrating impact and three CDCs were assigned to describe the damage. The CDCs were 12FDLW1 for the bumper fascia damage,

12TYRS1 for the right A-pillar and roof damage, and 12RPES1 for the right door damage. The WinSMASH program could not be used to calculate the Delta V for this event since yielding objects are out of scope for the program. The damage severity from the fence impact was minor.

The vehicle manufacturer's recommended tire size was P205/55R16. The Honda was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.

Figure6: Vertical max crush to roof

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	103	15	221	32	3	4	None	No	No
LR	Flat	Flat	221	32	6	7	None	No	Yes
RR	221	32	221	32	4	5	None	No	No
RF	214	31	296	43	4	5	None	Yes	No

Vehicle Interior: The inspection of the Honda's interior revealed evidence of occupant contact on the right front door arm rest (**Figure 7**). The arm rest was probably deformed from contact by the passenger's right hip during the rollover.

Figure 7 Deformed right arm-rest

Both doors remained closed and operational. All of the window glazing was either closed for operable windows or fixed for the others. The windshield was broken out post-crash and the left front window glazing disintegrated due to impact forces. There was no evidence of steering rim deformation or compression of the energy absorbing steering column.

There were four vertical intrusions of the passenger compartment. Intrusion measurements were taken on the roof and windshield header at the driver's position and were 7 cm (2.8 in) and 3 cm (1.2 in), respectively. The roof intrusion also involved the front right passenger and second row right passenger positions and these measured 6 cm (2.4 in) and 7 cm (2.8 in), respectively.

The Honda was not equipped with Electronic Stability Control (ESC), but was equipped with 4-wheel anti-lock disc brakes. The NHTSA has given the vehicle a four star rollover rating on a five star scale and a Static Stability Factor of 1.44[1]. A four star rating indicates that the vehicle has a 10%-20% chance of a rollover when involved in a single vehicle crash and the chance of rollover for this vehicle was rated at 10%. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistence to rollover. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50[2]. This vehicle model also did not tip-up in the dynamic steering maneuver test in which the test vehicle was put through a fish-hook shaped steering maneuver (i.e., hard left and hard right steer) at a speed of between 56 km/h-80 km/h (35-50 mph).

The Honda departed the roadway in a clockwise rotation as the driver was steering right. The vehicle's left side wheels left yaw marks through the weeds as it rotated and approached impact with the sign post and back slope of the ditch. As the left side wheels contacted the back slope, the opposing force on the left side wheels induced a roll moment, which tripped the vehicle. The vehicle rolled over left side leading 4 quarter turns across a distance of 14 m (45.9 ft) and came to final rest on its wheels.

EVENT DATA RECORDER

The Air Bag Control (ACM) module, which contains the Event Data Recorder (EDR) was removed from the vehicle and sent to NHTSA for forwarding to the vehicle manufacturer and imaging of the data. As of the date of this report, the EDR report has not been received from the manufacturer.

AUTOMATIC RESTRAINT SYSTEM

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, driver seat position sensor, safety belt buckle-mounted pretensioners, and a front right passenger weight sensor. The vehicle's front satellite impact sensors were located in the driver and passenger side front engine compartment. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Neither of these air bags deployed during the crash.

The vehicle was also equipped with front seat-mounted side impact air bags and roof side rail-mounted IC air bags. The vehicle's side impact sensors were located on each side of the vehicle within the lower B and C-pillars. Both IC air bags and front seat-mounted side impact air bags deployed in this crash.

---

[1] www.safercar.gov, 8/4/10

[2] "Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans", NHTSA Technical Report, DOT HS 809 868, June 2005

The Honda's IC air bags were located along the roof side rails inside the headliner, and extended from the top of the A-pillar to the C-pillar. The deployed left IC air bag was 135 cm (53.1 in) in width, 33 cm (13 in) in height, and the bottom edge was 13 cm (5.1 in) below the beltline. The air bag was tethered to the A-pillar with a 19 cm (7.5 in) nylon cord and the space between the front of the air bag and the A-pillar was 42 cm (16.5 in) at the approximate center of the air bag. The air bag was designed with inflation chambers adjacent to the front and second row outboard seat positions, and had a 3 cm (1.2 in) diameter vent port at the lower front of the air bag. The right passenger's IC air bag had the same dimensions. No contacts or damage were noted on both inboard and outboard sides of both air bags.

The driver's seat -mounted side impact air bag was located in the outboard side of the seat back and deployed through a tear-seam. The deployed air bag was oblong and there was an oval tether where both sides of the air bag were sewn together. The sewn area was 15 cm (5.9 inches) in width and 8 cm (3.1 in) in height, and was located in the middle of the air bag. There was also a 3 cm (1.2 in) diameter vent port located on the outboard side of the air bag. The deployed air bag was 52 cm (20.5 in) in height and 32 cm (12.6 in) in width. Inspection of the deployed air bag revealed no discernable evidence of damage or occupant contact, though there was a tear in the seat back fabric forward of the air bag that was probably due to deployment. The front right passenger's seat-mounted side impact air bag had the same dimensions. No contacts or damage were noted on the inboard and outboard sides of the air bag.

MANUAL RESTRAINT SYSTEM

The Honda was equipped with lap-and-shoulder safety belts in the front and second rows. The driver's safety belt was equipped with continuous loop belt webbing, a non-adjustable upper anchor, buckle and retractor-mounted pretensioners, sliding latch plate, and an Emergency Locking Retractor (ELR). The front right safety belt was similarly equipped, though it had an ELR/Automatic Locking Retractor (ALR). The second row safety belts were similar to the front left safety belt but were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed very light historical usage scratches on the latch plate and no load marks or stretching on the belt webbing. The buckle-mounted pretensioner actuated, retracting 4.5 cm (1.8 in). Based on this evidence and interviewee information, the driver was restrained during the crash.

Inspection of the front right passenger's safety belt revealed historical scratches and load marks on the latch plate as well as scuffs on the belt webbing. The belt webbing would not retract and the buckle-mounted pretensioner actuated, retracting 4 cm (1.6 in). Based on the belt webbing evidence and interviewee information, the front right passenger was restrained during the crash.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the Honda's driver [19-year-old female, 160 cm (63 in) and 57 kg (125 lbs)] was seated in an upright posture and turned slightly right, toward the center console. The interviewee stated that both occupants were turned toward the center console to look for an

object in the center console. The driver had both hands on the steering wheel, her seat track was located between the middle and forward positions, and her seat back was slightly reclined. The tilt steering column was located in its center position. The driver was not wearing any corrective lenses.

The interviewee recalled the driver steering to the right prior to the Honda departing the east road edge and rotating clockwise. The driver was slightly displaced to the left as a result of the impact with the sign post. As the vehicle traveled up the back slope of the ditch, the driver was displaced further to the left and toward the roof as the vehicle rolled over. While there was no discernable occupant contact evidence on either side impact air bag, occupant kinematic principles suggest that the left side of her torso probably loaded the seat-mounted side impact air bag and her head and left arm probably loaded the IC air bag. The driver sustained lacerations on the upper left shoulder and abrasions on the left elbow and knee, probably from flying glass fragments during the rollover. The driver remained restrained in her seat position through out the crash. She exited the vehicle without assistance through the right front door.

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to a local hospital where she was treated in the emergency room and released. She missed one day of work due to the crash and had no follow-up visits to a medical facility. The table below presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Lacerations (scratches) inside of upper left arm, near shoulder	minor 710602.1,2	Noncontact injury: flying glass, left front glazing	Probable	Interviewee (other occupant)
2	Abrasion left elbow, not further specified	minor 710202.1,2	Noncontact injury: flying glass, left front glazing	Probable	Emergency room records
3	Abrasion left proximal knee, not further specified	minor 810202.1,2	Noncontact injury: flying glass, left front glazing	Probable	Emergency room records

CASE VEHICLE FRONT ROW RIGHT PASSENGER KINEMATICS

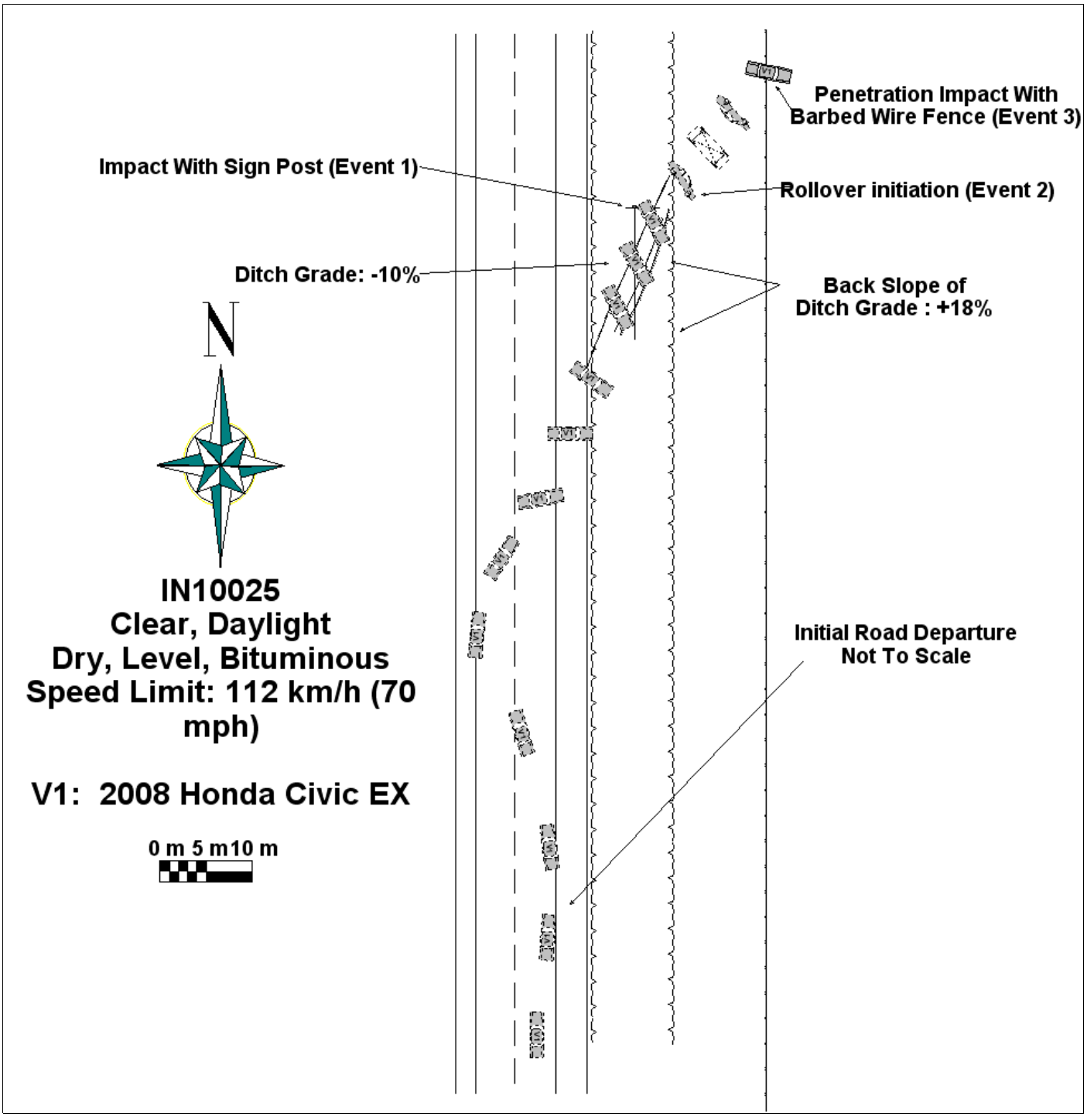
The Honda's front right passenger [19-year-old female, 155 cm (61 in) and 50 kg (110 lbs)] was seated in an upright posture and was turned to the left toward the center console. She stated that she had a camera in her right hand, which was resting in her lap and she was using her left hand to look for something in the console. As the vehicle traveled off the roadway and impacted the sign post and traversed up the back slope of the ditch, she was displaced to the left. As the vehicle rolled over and touched down on the roof and right roof side rail, she probably contacted her head on the right roof side rail, which caused a concussion. Her right hip also probably contacted the right door armrest. She sustained multiple abrasions and a laceration from flying

glass fragments. She remained restrained in her seat position throughout the crash. She exited the vehicle without assistance through the right front door.

CASE VEHICLE FRONT ROW RIGHT PASSENGER INJURIES

The front row right passenger lost consciousness at the crash scene as she was being treated by emergency medical personnel. She was transported by helicopter to a level 3 trauma center where she was treated in the emergency room and released. She did not miss any days of work due to the crash and had no follow-up visits to a medical facility. The table below presents the passenger's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Cerebral concussion with brief loss of consciousness at scene and memory impairment in ER	moderate 161002.2,0	Roof, right side rail	Probable	Emergency room records
2	Abrasion right upper back near axillary line, not further specified	minor 410202.1,6	Noncontact injury: flying glass, right front glazing	Probable	Emergency room records
3	Abrasion posterior right shoulder, not further specified	minor 710202.1,1	Noncontact injury: flying glass, right front glazing	Probable	Emergency room records
4	Lacerations (scratches) medial (inside) of upper right arm, near shoulder	minor 710602.1,1	Noncontact injury: flying glass, right front glazing	Probable	Interviewee (same person)
5	Abrasions posterior right leg–proximal thigh, posterior left leg–distal and proximal thigh, not further specified	minor 810202.1,3	Noncontact injury: flying glass, right front glazing	Possible	Emergency room records


Penetration Impact With Barbed Wire Fence (Event 3)
Impact With Sign Post (Event 1)
Rollover initiation (Event 2)
Ditch Grade: -10%
Back Slope of Ditch Grade : +18%
N
IN10025
Clear, Daylight
Dry, Level, Bituminous
Speed Limit: 112 km/h (70 mph)
V1: 2008 Honda Civic EX
0 m 5 m10 m
Initial Road Departure
Not To Scale