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ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN-06-007
LOCATION - TEXAS
VEHICLE - 2006 HONDA CIVIC LX
CRASH DATE - March 2006

Submitted:

October 27, 2006

Contract Number: DTNH22-01-C-07002

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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 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

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15. *Supplementary Notes* On-site air bag investigation involving a 2006 Honda Civic LX with manual safety belts, dual stage front air bags, side curtain air bags and front seat back-mounted side impact air bags.			
16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 2006 Honda Civic (case vehicle), which ran-off-road and impacted a concrete median barrier. This crash is of special interest because the case vehicle was involved in a rollover crash and was equipped with multiple Advanced Occupant Protection System (AOPS) features, and the case vehicle's driver (27-year-old, male) sustained a police reported "C" (possible) injury as a result of the crash. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle was traveling east in the inside through lane of a four-lane, divided U.S. highway. The driver lost control of his vehicle, entered the median, and the front left impacted the concrete median barrier. No frontal air bags deployed as a result of this impact. The impact with the median barrier caused the case vehicle to rotate clockwise, the back left rode up the median barrier and the case vehicle began to roll over, driver side leading. The top left portion of the trunk lid impacted the top of the median barrier during the second quarter roll. The right roof side rail then impacted the pavement. The case vehicle continued to roll over, landing on its wheels and then rolling over onto its roof for a total of six quarter rolls (i.e., one-and-one-half rolls). The case vehicle slid on its roof to final rest with the rear half of the vehicle in the median and front half in the inside lane heading north. Both side curtain air bags and the driver's seat back-mounted side impact air bags deployed during the rollover. The case vehicle's driver was not restrained by his manual, three-point, lap-and-shoulder belt. He sustained only minor injuries and was transported to a local hospital where he was treated and released.			
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TABLE OF CONTENTS

Page No.

This on-site investigation was brought to NHTSA's attention on or before April 21, 2006 by NASS CDS/GES sampling activities. This crash involved a 2006 Honda Civic LX (case vehicle), which ran-off-road into a concrete median barrier and rolled over. The crash occurred in March, 2006, at 3:20 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was involved in a rollover crash and was equipped with multiple Advanced Occupant Protection System (AOPS) features, an Event Data Recorder (EDR) and the case vehicle's driver [27-year-old, White (Hispanic) male] sustained a police reported "C" (possible) injury as a result of the crash. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Permission to harvest the Electronic Control Unit (ECM), which houses the EDR, was given by the insurance company on May 1, 2006. This contractor inspected the scene, case vehicle and harvested the RCM on May 2-3, 2006. This contractor interviewed the case vehicle's driver on May 11, 2006. This report is based on the police crash report, scene and vehicle inspections, EDR data, an interview with the case vehicle's driver, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling east in the inside through lane of a four-lane, divided U.S. highway at a driver reported speed of 113 km.p.h. (70 m.p.h.). The driver lost control of his vehicle and the front left of the case vehicle impacted the median barrier. No frontal air bags deployed as a result of this impact. The impact with the median barrier caused the case vehicle to rotate clockwise, the back left wheel impacted the median barrier and the vehicle rode up the median barrier and began to roll over, driver side leading. The top left portion of the trunk lid impacted the top of the median barrier during the second quarter roll. The right roof side rail then impacted the pavement. The case vehicle continued to roll over landing on its wheels and then rolling over onto its roof for a total of six quarter rolls (i.e., one-and-one-half rolls). The case vehicle slid on its roof to final rest with the rear half of the vehicle in the median and front half in the inside lane heading north. Both side curtain air bags and the driver's seat back-mounted side impact air bags deployed during the rollover.

The CDCs for the case vehicle were determined to be: **11-FYEW-1** (**330** degrees) for the frontal impact with the barrier (event 1), **09-LBWN-1** (**270** degrees) for the left rear wheel impact with the median barrier (event 2), **00-TDDO-2** for the rollover (event 3) and **00-TBYW-6** for the trunk impact with the barrier (event 4) that occurred during the rollover. The WinSMASH reconstruction program, barrier algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs for the front impact respectively as: 20.0 km.p.h. (12.4 m.p.h.), -17.3 km.p.h. (-10.8 m.p.h.), and 10.0 km.p.h. (6.2 m.p.h.). The collision fit the reconstruction model and the results appeared reasonable. Based on the extent of roof crush, the case vehicle's rollover severity was determined to be minor. The case vehicle was towed due to damage.

The case vehicle's driver was not restrained by his manual, three-point, lap-and-shoulder safety belt system. He sustained only minor injuries and was transported to a local hospital and

treated and released. The deployment of both side curtain air bags and the driver's seat back-mounted side impact air bag most likely mitigated his interaction with the case vehicle's interior during the rollover and reduced his injury potential.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a four-lane, divided, U.S. highway, traversing in an east-west direction. Each travel lane was approximately 3.7 meters (12 feet) in width. The median shoulder was composed of bituminous and was approximately 3 meters (10 feet) in width. The outside shoulder was composed of bituminous. Its width is not known. The trafficway was divided by a concrete median barrier of unknown height. Pavement markings consisted of a solid yellow median line, broken white center line and a solid white outside edge line. The posted speed limit was 97 km.p.h. (60 m.p.h.). At the time of the crash the light condition was dark, but illuminated by overhead street lamps, the atmospheric condition was clear, and the roadway pavement was dry bituminous with a positive grade that appeared to be less than 2%. There was no other traffic present, and the site of the crash was commercial/residential. See the Crash Diagram at the end of this report.

Figure 1: Approach of case vehicle eastbound in inside through lane, arrow show possible location of impact

Pre-Crash: The case vehicle was traveling east in the inside through lane (**Figure 1**) at a driver reported speed of 113 km.p.h. (70 m.p.h.). The driver was intending to continue eastbound. The case vehicle's driver stated that a pedestrian was in the roadway. The driver stated he steered left to avoid hitting the pedestrian and lost control of the vehicle. There was no mention of a pedestrian in the roadway on the police crash report. The police crash report simply stated that the driver was speeding and lost control of his vehicle. The driver does not remember if he applied the brakes or made any other maneuver to avoid the impact with the median barrier. The crash occurred in the median at the median barrier.

Figure 2: Overview of damage to front of case vehicle from impact with median barrier and damage from roll over, increments on tape measure on hood are in tenths of meter, each increment on rods is 5 cm (2 in)

Crash: The front left of the case vehicle (**Figure 2**) impacted the concrete median barrier (**Figure 3** below). No frontal air bags deployed as a result of this impact. The front impact caused the case vehicle to rotate clockwise and the back left wheel impacted the median barrier (**Figure 3** below) most likely deploying the left side curtain and side impact air bags. The case vehicle then rode up the barrier and began to roll over, driver side

leading. The top left portion of the trunk lid impacted the top of the median barrier during the second quarter roll (**Figure 4**). The right roof side rail then impacted the pavement (**Figure 5**), most likely causing the case vehicle's right side curtain air bag to deploy. The case vehicle continued to roll over, landed on its wheels and then on its upper left side (**Figure 6**). The case vehicle then continued over onto its roof for a total of six quarter rolls (i.e., one-and-one-half rolls).

Figure 3: Damage to left rear wheel (arrow) from impact with median barrier, wheel angled in at bottom

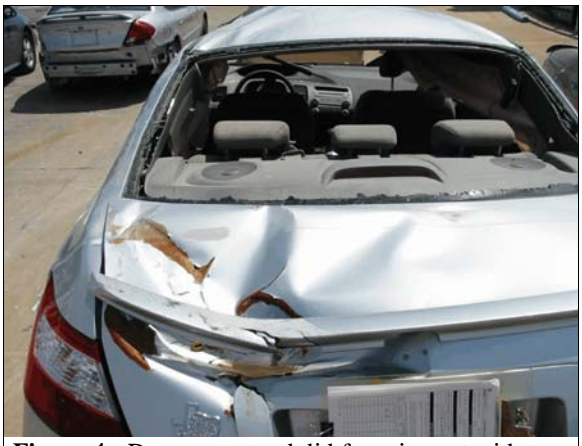


Figure 4: Damage to truck lid from impact with top of median barrier during rollover

Figure 5: Overview of rollover damage to right side and top of case vehicle

Figure 6: Rollover damage to hood, roof and upper left side

Post-Crash: After the case vehicle landed on its roof during its last quarter roll, it slid along the pavement. The distance the case vehicle slid on its roof is not known. It stayed on its roof and slid to final rest with the rear half of the vehicle in the median and front half in the inside lane heading north.

CASE VEHICLE

The 2006 Honda Civic LX was a front wheel drive, two-door coupe (VIN: 2HGFG12606H------). The manufacturer of this vehicle has certified that it meets the

advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle was equipped with a 1.8L, 4-cylinder engine; five-speed automatic transmission and four-wheel anti lock brakes. The front seating row was equipped with bucket seats with seat back-mounted side impact air bags, active head restraints, side curtain air bags; dual stage, dual threshold front air bags and manual, three-point, lap and shoulder safety belt systems with usage sensors, and buckle and retractor-mounted safety belt pretensioners. In addition, the front right passenger seat was equipped with an Occupant Position Detection System (OPDS). The back seating row was equipped with a bench seat with adjustable head restraints and manual, three-point, lap-and-shoulder safety belts and side curtain air bags. The back seat was also equipped with a LATCH system for securing child safety seats. The case vehicle's wheelbase was 265 centimeters (104.3 inches). The case vehicle's odometer reading at the time of the inspection is unknown because the case vehicle was equipped with an electronic odometer.

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity, safety belt usage and presence of a front right passenger to determine the front air bag inflation level appropriate for the severity of the crash. The OPDS utilizes seven sensors in the front right passenger's seat back and seat bolster to detect the size and seating position of the passenger. If a child or small-statured adult is leaning into the deployment path of the side impact air bag, an indicator light on the instrument panel notifies the driver that the side impact air bag is suppressed. The air bag is enabled and the light goes out three seconds after the passenger returns to an upright position. In addition, sensors for the side impact and side curtain air bags are located along both sills and at both "B" pillars. If a side impact of sufficient severity is detected, a deployment of the appropriate side curtain and side impact air bags is commanded.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial contact with the concrete median barrier involved the frontal plane with damage distributed mostly to the left portion. The front bumper, bumper fascia, grille, left turn signal/headlamp assemblies, hood, and left fender were directly damaged and crushed rearward as well as displaced to the right. Direct damage began at the left bumper corner and extended 65 centimeters (40.3 inches), along the front bumper. Residual maximum crush (**Figure 7** below) was measured as 19 centimeters (7.5 inches) occurring at C_1. The left side wheelbase was shortened 13 centimeters (5.1 inches), while the right side wheelbase was shortened 1 centimeter (0.4 inches). There was induced damage to both the right headlamp/turn signal assemblies as well as the hood, and right fender. The table below shows the case vehicle's front crush profile for the impact with the median barrier.

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	65	19	119	19	14	13	11	7	5	-54	0
in		25.6	7.5	46.9	7.5	5.5	5.1	4.3	2.8	2.0	-21.3	0.0

The case vehicle sustained damage to the left rear wheel rim from contact with the median barrier. The trunk contact with the median barrier that occurred during the rollover involved the top left portion of the trunk. Direct damage began at the top left corner near the bottom of the "C"-pillar and extended diagonally to the back edge, damaging the spoiler. Direct rollover damage was observed on the case vehicle's hood, right and left A-pillars, roof side rails, right quarter panel, "C"-Pillars, right fender, left rear wheel and the roof. In addition, all side glazing was broken out except for the left rear window. The windshield was out-of-place, but this did not appear to be related to the crash. Lastly, based on measurements from the case vehicle and an exemplar vehicle, the maximum vertical and maximum lateral crush to the case vehicle's greenhouse was determined to be 6 centimeters (2.4 inches) and 4 centimeters (1.5 inches) respectively (**Figures 8** and **9**).

Figure 7: Left side view of crush to front of case vehicle

Figure 8: Arrow shows location of maximum vertical crush located at right windshield header

Figure 9: Case vehicle's maximum lateral crush located at top of right "A"-pillar

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

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	179	26	221	32	7	9	None	No	No
RF	179	26	221	32	6	7	None	No	No
LR	296	43	221	32	5	6	Sidewall scuffed, rim abraded, wheel bent inward	Yes	No
RR	179	26	221	32	7	9	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figure 10** and **Figure 11** below) revealed no evidence of occupant contact to any of the interior surfaces or components. A few small scuffs were observed on the roof over the back seat; however, these scuffs were not likely related to occupant contact. The driver most likely contacted the deployed side curtain air bags and his seat back-mounted side impact air bag; however, no obvious occupant contact evidence was observed on these air bags. The case vehicle sustained several intrusions to the passenger compartment. The left A-pillar was intruded 3 centimeters (1.2 inches) vertically and 1 centimeter (0.39 inches) laterally while the right A-pillar was intruded 3 centimeters (1.2 inches) vertically and 4 centimeters (1.6 inches) laterally. In addition, the roof was intruded 2 centimeters (0.8 inches) at the driver's position, 4 centimeters (1.6 inches) at the front middle position, and 9 centimeters (3.5 inches) at the front right position. Lastly, there was no evidence of compression of the energy absorbing steering column or deformation of the steering wheel (**Figure 12** below).

Figure 10: Overview of case vehicle's steering wheel, instrument panel and left "A"-pillar

Figure 11: Right side view of case vehicle's left front door, steering assembly and left "A"-pillar

Figure 12: Left side view of case vehicle's steering wheel and steering assembly showing lack of deformation

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **11-FYEW-1** (**330** degrees) for the frontal impact with the barrier (event 1), **09-LBWN-1** (**270** degrees) for the left rear wheel impact with the median barrier (event 2), **00-TDDO-2** for the rollover (event 3) and **00-TBYW-6** for the trunk impact with the barrier (event 4),. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact (event 1). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 20 km.p.h. (12.4 m.p.h.), -17.3 km.p.h. (-10.8 m.p.h.), and 10 km.p.h. (6.2 m.p.h.). The collision fit the reconstruction model and the results appeared reasonable. Based on the extent of roof crush, the case vehicle's rollover severity was determined to be minor. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with manufacturer certified advanced 208-compliant air bags at the driver and front right passenger positions. Neither of the front air bags deployed. The case vehicle's ECU determined that deployment of the driver's front air bag was not required. The front right passenger's air bag was suppressed because no front right passenger was present at the time of the cash. The case vehicle was also equipped with seat back-mounted side impact air bags and side curtain air bags. The driver's seat back-mounted side impact air bag and both side curtain air bags deployed as a result of the rollover.

The driver's seat back-mounted side impact air bag was located in the outboard side of the driver's seat back (**Figure 13** below). The air bag (**Figure 14** below) was approximately oval in shape and measured approximately 52 centimeters in height (20.5 inches) and 38 centimeters (15 inches) in width. It was designed with one vent port 3.5 centimeters (1.4 inches) in diameter located at the front, central outboard side of the air bag. There was a double-stitched oval section of material, approximately 16 centimeters (6.3 inches) in length, in the central portion of the air bag where both sides of the air bag were sewn together. This appeared to shape the inflation

chamber during deployment. There was no evidence of occupant contact to this air bag. However, a large probable deployment scuff was noted on the central portion of the outboard surface of the air bag (**Figure 15**).

Figure 13: Location of case vehicle driver's seat back- mounted side impact air bag

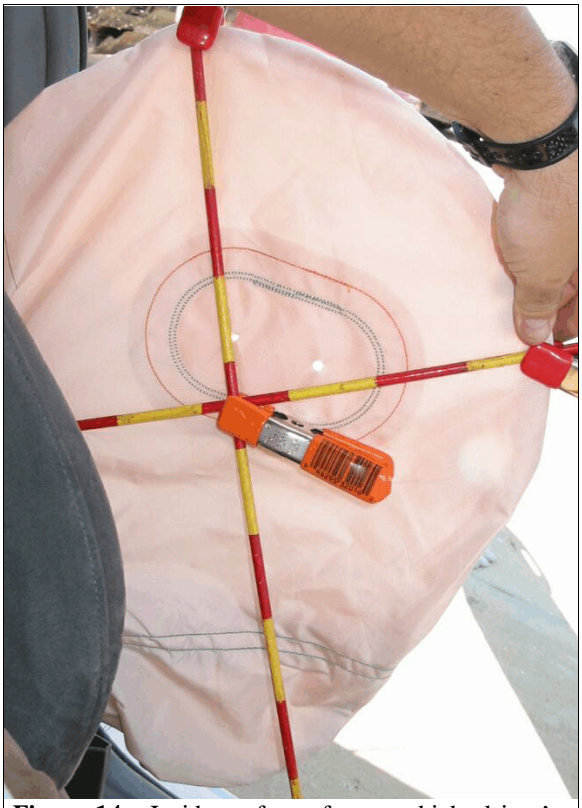


Figure 14: Inside surface of case vehicle driver's seat back- mounted side impact air bag

The left side curtain air bag was located along the left roof side rail, inside the head liner (**Figures 16** and **17** below). The air bag extended along the side rail from the middle of the A-pillar, across the front left and back left seat positions to the "C"-pillar. The air bag was attached to the "A"-pillar by a cloth anchor cord approximately 20 centimeters (7.9 inches) in length. There was no evidence of damage during the deployment to the air bag. However, a small cut in the inboard surface of the air bag was observed on the front inflation chamber near the roof side rail (**Figure 18** below). This was most likely related to broken glass as the driver exited the vehicle through the left front window. The left side curtain air bag was approximately 134 centimeters (52.8 inches) in length and 35 centimeters (13.8 inches) in height. It was constructed with two primary

Figure 15: Outside surface of case vehicle driver's seat back-mounted side impact air bag, arrow shows probable deployment related scuff

inflation chambers, one at the driver's head area and one at the left rear passenger's head area. The inflation chamber adjacent to the driver's seat had four circular, double-stitched areas where both sides of the air bag were sewn together. The inflation chamber adjacent to the back left seat had one of these double-stitched areas. Based on crash test videos, this appears to aid in shaping the air bag during inflation and to control the width of the air bag during deployment. While there were no obvious vent ports, an area of perimeter stitching at the front and rear of the air bag did not meet leaving an opening, presumably to allow the inflation gases to escape the inflation chambers.

Figure 16: Front and back portion of the case vehicle's left side curtain air bag

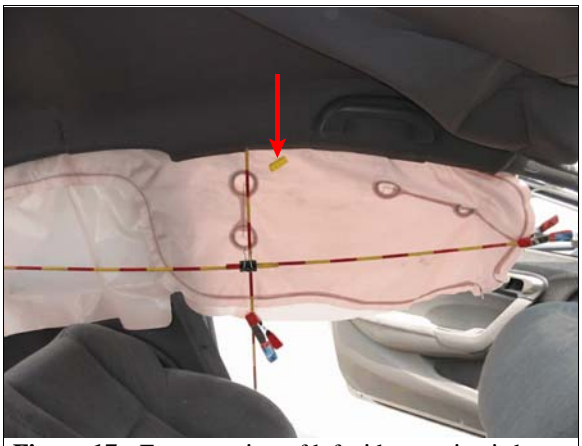


Figure 17: Front portion of left side curtain air bag, arrow shows location of small cut in bag, probably due to broken glass as driver exited the vehicle through the left front window

The right side curtain air bag was the same design and dimensions as the left side curtain air bag. The front portion of the air bag was found entrapped between the front right seat head restraint and the intruded roof (**Figure 18**). This most likely occurred during the sixth and final quarter roll as the case vehicle landed on its roof. Otherwise, the right side curtain air bag was unremarkable.

Figure 18: Right side curtain air bag was found entrapped between front right seat head restraint and roof

CRASH DATA RECORDING

The event data analysis provided by the manufacturer indicated that the case vehicle was equipped with one "row" of sensors for the side curtain air bags and one "row" of sensors for the seat back-mounted side impact air bags. The report indicated that one row of sensors was located at each "B"-pillar and the other row of sensors was located at each sill. The data analysis indicated that the driver and front right passenger safety belt status was recorded as unbelted, and neither the driver's nor the front right passenger's pretensioners activated. The OPDS status for the front right passenger seat was indicated as empty, and the deployment of the front right seat back-mounted side impact air bag

was suppressed ("Inhibit"). The data analysis indicated that only the right side curtain air bag was commanded to deploy. The side air bag ECU "On Time" was indicated as 63.5 milliseconds. The right side crash sensor "On Time" was indicated and 29 milliseconds. The data analysis regarding side air bag deployments conflicted with the evidence from the case vehicle inspection, which showed both side curtain air bags and the driver's seat back-mounted side impact air bags deployed.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [27-year-old, White (Hispanic) male; 175 centimeters and 91 kilograms (69 inches, 200 pounds)] was seated in an upright position with his back against the seat back, his left foot on the floor, his right foot in an unknown position, and both hands most likely on the steering wheel. His seat track was located in its middle position, the seat back was slightly reclined, and the tilt steering column was located in its center position.

Based on the vehicle inspection and supported by the EDR data, the driver was not restrained by his manual, three-point, lap-and-shoulder safety belt system. Inspection of the safety belt assembly revealed no evidence of loading.

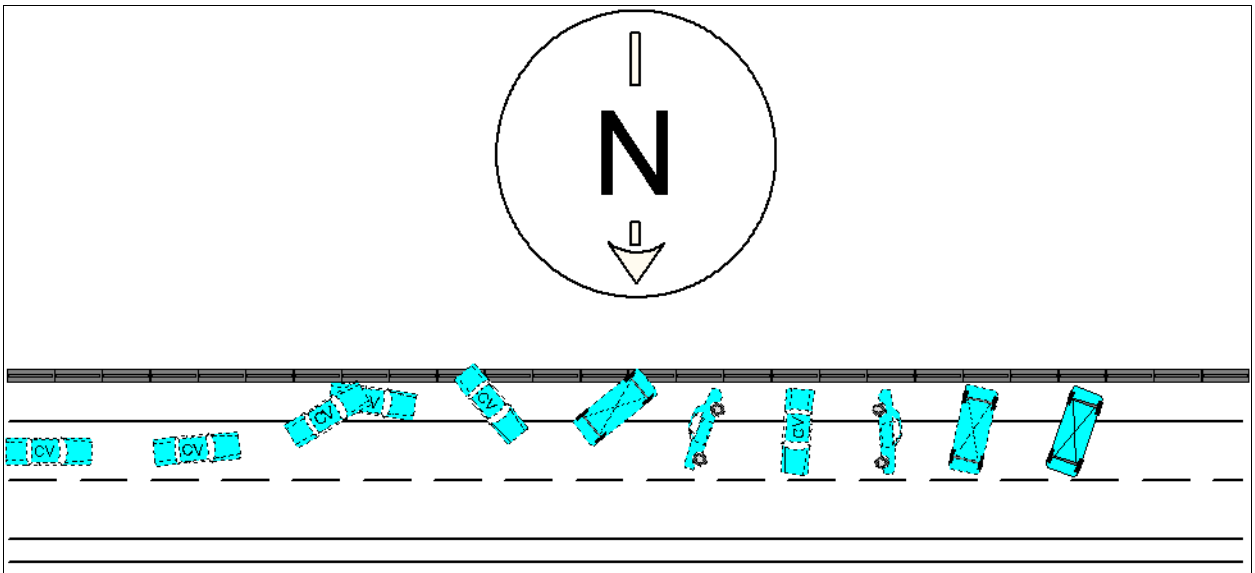
The case vehicle's impact with the median barrier caused the driver to continue forward and left along a path opposite the case vehicle's 330 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the right. As the case vehicle deflected right, rotated clockwise and rode up the median barrier, the left rear wheel impacted the barrier most likely deploying the left side curtain air bag and driver's seat back-mounted side impact air bag. As a result, the driver moved left opposite the case vehicle's 270 degree direction of principal force as the case vehicle decelerated and his head most likely contacted the deployed side curtain air bag and his left shoulder and upper arm most likely contacted the side impact air bag. The driver was likely out of position due to the front impact and the non-use of his lap-and-shoulder belt and most likely contacted the forward portion of his deployed side impact air bag. The driver moved toward the roof as the case vehicle continued to rotated clockwise and rolled over driver side leading. He most likely came out of his seat and his head and shoulders most likely contacted the roof as the top of the trunk lid impacted the top of the median barrier. The driver moved to the right and most likely contacted the right front door and the deployed right side curtain air bag as the case vehicle's right roof side rail impacted the pavement during the third quarter roll. He most likely remained in the front seat area as the case vehicle continued to roll over onto its wheels and left side and contacted to roof again as the case vehicle landed on its roof on the sixth and final quarter roll and slid to final rest. The driver came to rest on the roof most likely in the front seat area. The driver stated he exited the case vehicle under his own power through the left front window.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver sustained a police reported "C" (possible) injury and was transported by ambulance to the hospital. He was treated and released from the emergency room.

The driver's emergency room record indicated that the driver left the hospital against medical advice and appeared anxious. The emergency room record also indicated the treating physician was suspicious that the driver was under the influence of "mood altering drugs". The driver reported that he did not lose any work days as a result of the crash and sought no follow-up treatment. The table below shows the case vehicle driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasions on lower back, not further specified	minor 690600.1,8	Noncontact injury: flying glass, unknown source	Possible	Emergency room records
2	Contusion back (most likely lower), not further specified	minor 690402.1,8	roof	Possible	Emergency room records
3	Abrasions on right posterior distal upper arm	minor 790600.1,1	Noncontact injury: flying glass, unknown source	Possible	Emergency room records
4	Strain left shoulder muscle, not further specified	minor 740402.1,2	roof	Possible	Interviewee (driver)
5	Sprain right knee, not further specified	minor 850826.2,1	Left instrument panel and below	Probable	Interviewee (driver)



IN-06-007

Clear, Dark, but Illuminated by Street Lamps
Dry, Level Concrete
Estimated Coefficient Of Friction = 0.70

CV = 2006 Honda Civic LX

Sketch