On-Site Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS08018
2006 Honda Civic LX Coupe
Washington
May 2008

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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.

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16. Abstract

This on-site investigation focused on the dynamics of a 2006 Honda Civic LX Coupe that was involved in a rollover crash. The vehicle was being driven by a 24-year-old male and was traveling on an interstate highway.

The Honda was traveling northbound in the second lane from the right. Police reported that the driver fell asleep and the vehicle drifted to the right in the approach to an off-ramp. The vehicle traveled across the outboard lane and the right shoulder, and contacted an impact attenuator that divided the highway from the exit ramp. Following the impact with the impact attenuator, the vehicle rotated clockwise, returned to the roadway, and initiated a right side leading turn over. The Honda rolled three quarter-turns and came to rest on its left side and facing northwest in the second and third lanes.

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Background

This on-site investigation focused on the dynamics of a 2006 Honda Civic LX Coupe that was involved in a rollover crash. The vehicle was being driven by a 24-year-old male and was traveling on an interstate highway.

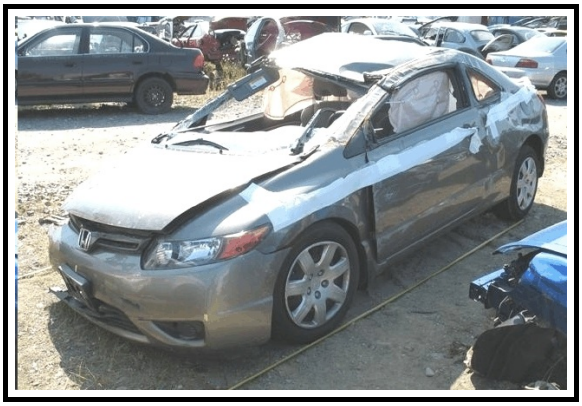

Figure 1. Subject vehicle, 2006 Honda Civic LX Coupe

The Honda was traveling northbound in the second lane from the right. Police reported that the driver fell asleep and the vehicle drifted to the right in approach to an off-ramp. The vehicle traveled across the outboard lane and the right shoulder, then contacted an impact attenuator that divided the highway from the exit ramp. Following the impact with the impact attenuator, the vehicle rotated clockwise, returned to the roadway, and initiated a right side leading turn over. The Honda rolled three quarter-turns and came to rest on its left side facing northwest in the second and third lanes.

During the crash, the Honda impacted the impact attenuator with sufficient force to displace one section of the barrier to the right. A 2006 Chevrolet Trailblazer was traveling on the exit ramp near the time of the Honda's impact with the barrier. The Chevrolet's left side rear contacted the displaced barrier as it passed by. It is not known how much time passed between the Honda's impact to the barrier and the Chevrolet's impact to the barrier, or if the barrier was in the process of being displaced when it contacted the Chevrolet.

This rollover investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) during a review of police reports from the National Automotive Sampling System (NASS) General Estimates System (GES). The report indicated the subject vehicle deployed a side air bag during a rollover crash. DSI was sent the report on June 24, 2008 and instructed to locate the subject vehicle. The Honda (**Figure 1**) was located at an auto salvage facility, and on June 25, 2008, DSI obtained permission to inspect the vehicle. The case was assigned on June 26, 2008 and the inspection was completed on June 30, 2008. The Honda's Event Data Recorder (EDR) was not supported by the Bosch Crash Data Retrieval hardware and software, and permission to remove the vehicle's EDR was not obtained.

Summary

Crash Site

The crash site was the northbound lanes of a three lane divided north/south interstate highway. The roadway was configured with a right curve followed by a left curve and a slight uphill grade. The interchange comprised a right exit ramp, which was physically divided from the highway by the impact attenuators and concrete traffic barriers (**Figure 2**). The roadway surface was asphalt and narrow shoulders and concrete traffic barriers were present on either side. The inboard lane was a

high occupancy vehicle (HOV) lane and the remaining two lanes were unrestricted. The unrestricted travel lanes were separated by white reflective markers and the HOV lane was separated by a solid white line. Highway construction activity was present in the area east of the outboard lane and on the exit ramp. The speed limit for the highway was 97 kmph (60 mph).

Figure 2. Crash location, northbound approach

The crash occurred at 1951 hours in May 2008. The weather was clear with no precipitation and the roadway was dry. At the time of the crash, conditions were daylight with streetlights not illuminated.

Pre-Crash

The Honda was being driven northbound by a 24-year-old male who had fallen asleep. The Honda was traveling in the second lane from the right at an unknown speed. As the roadway alignment changed to a slight left curve the vehicle drifted to the right, crossed the outboard lane and departed the roadway on the right side.

Crash

The Honda's front end impacted an impact attenuator that separated the outboard lane from the exit ramp (Event 1). During the impact, the driver's frontal air bag deployed. While the Honda and the attenuator were engaged, the vehicle initiated a clockwise rotation and the contact damage was distributed across its front end. The vehicle returned to the roadway and continued rotating clockwise until it had rotated 220 degrees from its original heading angle. The vehicle then initiated a right side leading turn over and rolled three quarter-turns (Event 2). During the rollover, the vehicle traveled in a northwest trajectory across the three lanes. It came to final rest on its left side and facing northwest in the second and third lanes from the right. During the rollover, the vehicle's left seat-mounted side air bag and left and right side curtain air bags deployed.

Post-Crash

It is unknown how the driver exited the vehicle, but it is presumed he remained in the vehicle until emergency personnel arrived because the vehicle exhibited evidence of extrication activity. The left and right A-pillars were cut through near the windshield header, and the right roof side rail and window frames were cut through just forward of the right B-pillar. From the right roof side rail, the roof was cut laterally to the left roof side rail, which remained intact. The extrication damage indicated that the roof was then pulled away from the vehicle so that the driver could exit through the opening. The driver's safety belt was cut through in two places.

The driver of the Honda was reported by police to have sustained a possible injury to his left arm. It is unknown if he was transported or treated for injuries following the crash. The Honda was towed from the scene due to damage, was later declared a total loss by the insurance company, and was sold

to an auto salvage facility.

Vehicle Data

The Honda was identified by the Vehicle Identification Number (VIN): 2HGFG11626Hxxxxxx. The vehicle's data of manufacture was April 2006. The mileage was unavailable due to the electronic odometer and absence of power to the vehicle. The vehicle was equipped with a 1.8-liter, 4-cylinder engine, 5-speed manual transmission, front wheel drive, 4-wheel anti-lock braking system (ABS), Electronic Brake Distribution (EBD), daytime running lights, and power steering with tilt and telescoping column functionality.

The Honda was configured with an Advanced Compatibility Engineering (ACE) body structure. The ACE body structure was designed to improve impact compatibility with different sized vehicles in multiple-vehicle impacts, and enhance occupant protection in frontal impacts. In front end impacts, the frame design redirects crash energy around the passenger compartment.

The vehicle manufacturer's recommended tire size was P205/55R16 for the front and rear, and the recommended cold tire pressure was 221 kPa (32 psi) for the front and rear. The vehicle was equipped with Bridgestone Turanza EL400 P205/55R16 tires on the left front, left rear, and right rear positions. The tire manufacturer's recommended maximum tire pressure was 275 kPa (40 psi). The right front tire was displaced from the vehicle during the crash and was not inspected. Therefore, the tire manufacturer, model, and specifications were unknown. The specific tire information for the remaining tires was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	179 kPa (26 psi)	6 mm (8/32 in)	No	None
LR	200 kPa (29 psi)	6 mm (8/32 in)	No	None
RR	207 kPa (30 psi)	6 mm (8/32 in)	No	None
RF	Unknown			

The Honda's front row seating was configured with fabric-covered bucket seats with folding backs and adjustable head restraints for the two outboard seating positions. The second row seating was configured with a fabric-covered bench seat with separate back cushions for the three seating positions.

Vehicle Damage

Exterior Damage

The Honda sustained moderate front end and right side damage as a result of the frontal impact with the traffic barrier. A section of the front right bumper, right front rim/tire, and right front fender were displaced from the vehicle during the crash (**Figure 3**). Those components could not be located and

therefore were not inspected. As the Honda engaged the impact attenuator, the vehicle rotated clockwise approximately 90 degrees and the contact damage was distributed across the front end. Direct damage for the frontal impact began at the front left bumper corner and extended 144 cm (56.7 in) to the right. An estimated 12 cm (4.7 in) of additional direct damage would have extended to the front right bumper corner that was torn from the vehicle.

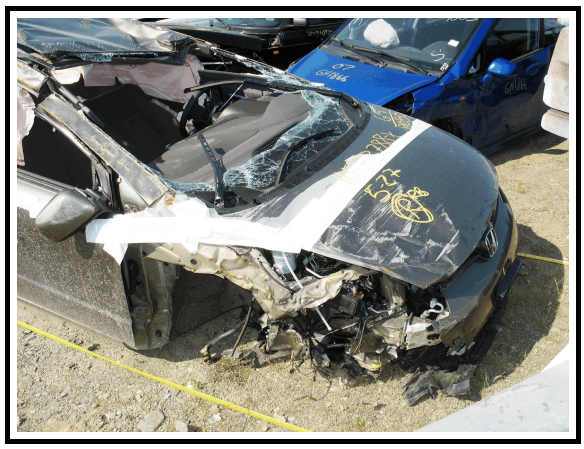

Figure 3. Front end and right side damage

Six crush measurements were taken at bumper level to the existing bumper fascia and to the backing bar where the fascia was missing. The crush measurements were as follows: C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 0 cm, C5 = 5 cm (2.8 in), C6 = 10 cm (3.9 in). The maximum crush was located at C6. The Collision Deformation Classification (CDC) for the Event 1 was 12FDEW1. The damage to the right front rim and axle was not included in the CDC due to National Automotive Sampling System (NASS) coding conventions.

A WinSMASH calculation was generated based on the crush damage sustained during Event 1. The Barrier algorithm of the WinSMASH program generated a Total Delta-V of 15 km/h (9 mph), and lateral and longitudinal Delta-V components of -15 km/h (- 9 mph) and 0 km/h, respectively. The results appear reasonable based on the vehicle's front end crush profile.

After the vehicle disengaged the impact attenuator, the Honda initiated a right side leading turn over, rolled three quarter turns, and came to final rest on its left side.

Direct damage from the rollover was located on the vehicle's left and right sides, roof, and hood. There was direct damage to the left A-, B- and C-pillars, and right A-pillar. The direct damage to the left side began at the front left bumper corner, extended rearward 373 cm (147 in), and ended 43 cm (17 in) aft of the rear axle. The damage extended vertically from the sill to the roof rail and there were scuff marks on the left side rims.

The right front fender, rim and tire, and right end of the front bumper were displaced from the vehicle during the frontal impact (Event 1). The direct damage to the intact right side components began 68 cm (26.8 in) forward of the rear axle, extended forward 197 cm (77.6 in), and ended at the right A-pillar. The damage was located primarily along the right side roof rail and upper pillars.

The direct damage to the top included the hood, windshield and roof. The damage began at the front of the hood, extended rearward 260 cm (102.4 in) and ended 76 cm (29.9 in) forward of the rear axle. The direct damage to the top was distributed laterally 114 cm (44.9 in) from roof side rail to roof side rail.

The maximum lateral crush sustained in the rollover event was located at the top left A-pillar, lateral to the top of the windshield , and measured 6 cm (2.4 in). The maximum vertical crush sustained in the rollover was located at the left roof, 25 cm (9.8 in) right of the left roof side rail, and measured

12 cm (4.7 in). The CDC for Event 3 was 00TYDO3.

Extrication related damage was present on the vehicle's exterior and interior. The left and right A-pillars, right roof side rail, front row right window frame, and roof were cut through. The driver's safety belt was cut through in two places, and a section of the right side curtain air bag was cut away.

Interior Damage

The Honda sustained interior damage as a result of the rollover. The windshield was out of place and holed, probably as a result of extrication activity. The interior A-pillar cover was displaced beginning at its upper aspect and extending down to the left instrument panel (**Figure 4**). The glazing was disintegrated at the left front and rear, right front, and backlight windows. Three of the five head restraints were missing from the seat backs, probably as a result of extrication activity.

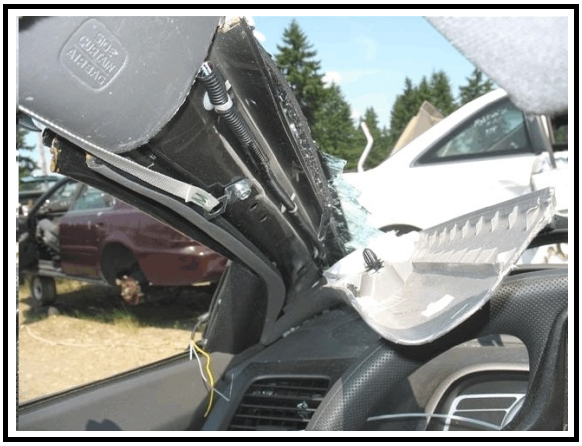

Figure 4. Interior damage, left A-pillar

The passenger compartment intrusions were confined primarily to the front row left area, in close proximity to the driver. The intruded components included the left A-pillar, left roof, left and center windshield header, and left roof side rail.

Manual Restraints

The Honda was equipped with 3-point manual lap and shoulder belts for the five seating positions. The belts were configured with sliding latch plates, all of which were scratched and showed evidence of historical usage. The driver's belt was equipped with an emergency locking retractor (ELR) and the remaining belts were equipped with ELR/automatic locking retractors (ALR). The front safety belts were equipped with dual position pretensioners which were located at both the retractor and buckle locations.

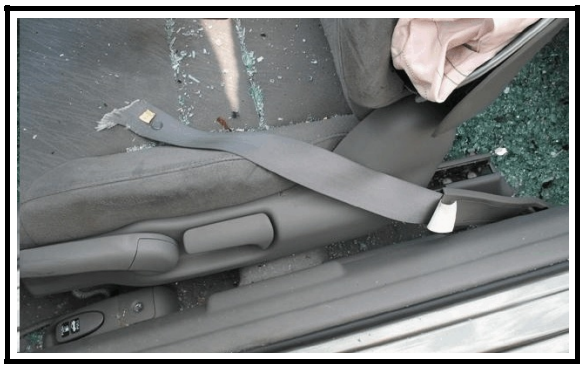

Figure 5. Driver's safety belt webbing was cut during extrication efforts.

The driver's safety belt webbing was cut through in two places: at the lap portion of the belt webbing near the stop button (**Figure 5**) and near the D-ring. The safety belt webbing was cut by emergency personnel during extrication activity. A section of webbing that was cut away was missing and therefore was not examined. The latch plate was found by the DSI investigator in the buckled position (**Figure 6**). Neither the latch plate, the safety belt webbing nor the D-ring evidenced occupant loading. However, based on the extrication damage to the safety belt webbing and the driver's kinematics, it was determined that the driver's safety belt was used during the crash. The driver's safety belt buckle stalk was examined and measured. The

flexible section of stalk measured 6 cm (2.4 in). The right side buckle stalk measured the same length. Later, the buckles of an exemplar vehicle were measured and yielded identical results. It was determined the driver's buckle pretensioner did not actuate, based on these measurements. The shoulder portion of the driver's safety belt webbing was found retracted into the B-pillar. The safety belt was configured with an ELR retractor and a retractor pretensioner, and the retractor was not locked in place due to pretensioner actuation. Based on the functional retractor, it was determined that the retractor pretensioner did not actuate during the crash.

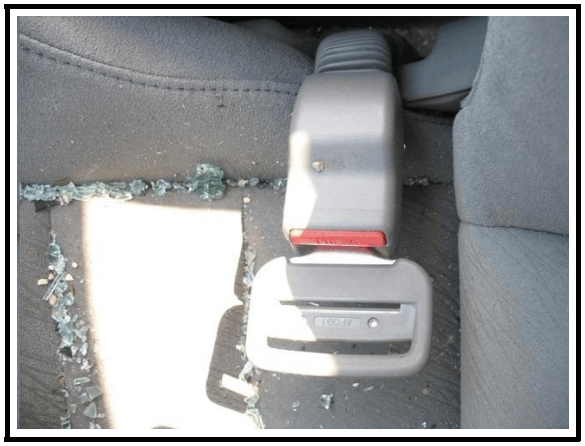

Figure 6. Driver's safety belt latch plate was found in buckled position

All seating positions in the vehicle were equipped with adjustable head restraints. The driver's and the second row outboard head restraints were missing from the seat backs and were found within the second row of the vehicle. The displaced head restraints did not present any damage or contact evidence.

The Honda was equipped with Lower Anchors and Tether Hardware for Children (LATCH) to accommodate child restraints. The hardware included lower anchors for the second row outboard seats and upper tether hardware for the second row left, middle and right seats.

Supplemental Restraint System

The Honda's Supplemental Restraint System (SRS) included an air bag control module, driver and passenger frontal air bags, seat-mounted side air bags, side curtain air bags, front and side impact air bag sensors, and safety belt pretensioners for the driver and front right passenger.

The Honda was a Certified Advanced 208-Compliant (CAC) vehicle. A CAC vehicle is certified by the manufacturer to be compliant with the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

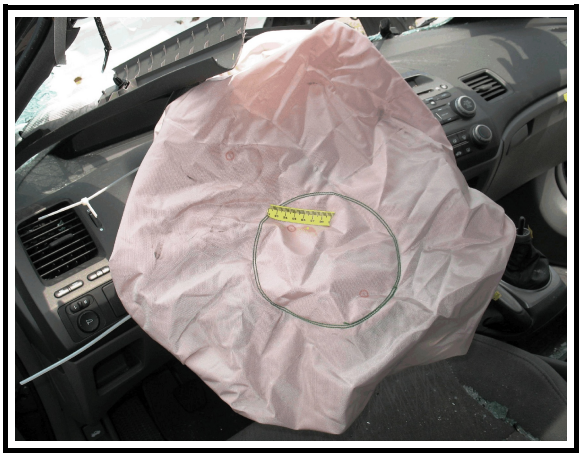

Figure 7. Driver's frontal air bag

The vehicle's advanced dual-stage frontal air bags were designed to deploy according to impact severity. Front seat sensors determined whether the air bags should inflate; the appropriate power of inflation was based on occupant weight. The driver's frontal air bag deployed during Event 1 due to sufficient longitudinal deceleration at impact with the impact attenuator.

The driver's frontal air bag deployed from the steering wheel hub through one upper and two lower

cover flaps (**Figure 7**). It was configured with two circular vent ports and two internal tethers. The air bag was circular in shape and measured 47 cm (18.5 in) in diameter in its deflated state. The front center of the bag was configured with a circular stitching pattern that measured 16 cm (6.3 in) in diameter. Within the stitched circle was a yellow-colored fabric transfer which covered an area 5 x 2 cm (2.0 x 0.8 in). This transfer mark was a result of driver contact with the air bag.

The driver's seat-mounted side air bag deployed during the rollover event (**Figure 8**) from a module in the outboard aspect of the driver's seat back. The air bag measured 52 cm (20.5 in) in height and 40 cm (15.8 in) in width in its deflated state. The air bag was configured with a single vent port and no tethers. Faint transfers were present on the outboard aspect of the air bag as a result of contact to the interior door panel during the deployment. There was no evidence of occupant contact or damage on the air bag.

The side curtain air bags were monitored by side impact sensors, and deployed during the rollover event. They provided head protection coverage for the first and second row outboard seating positions (**Figures 9-10**). The side curtain air bags deployed from a configuration of three in-line flaps from the left and right roof rails and measured 140 cm (55.1 in) in length and 35 cm (13.8 in) in height. Each was configured with a single external tether at its forward aspect.

During extrication activity, the right side curtain air bag was cut from bottom to top near the B-pillar at 65 cm (25.6 in) aft of the forward aspect. The tether strap was cut or torn into two pieces; a section of tether remained attached to the bag and another was attached to the roof rail.

The front right passenger's seat was unoccupied and the frontal air bag was suppressed. The right seat-mounted side air bag did not deploy.

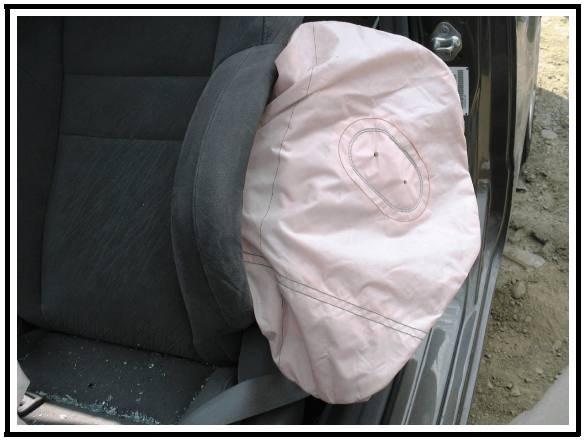

Figure 8. Left seat-mounted side air bag

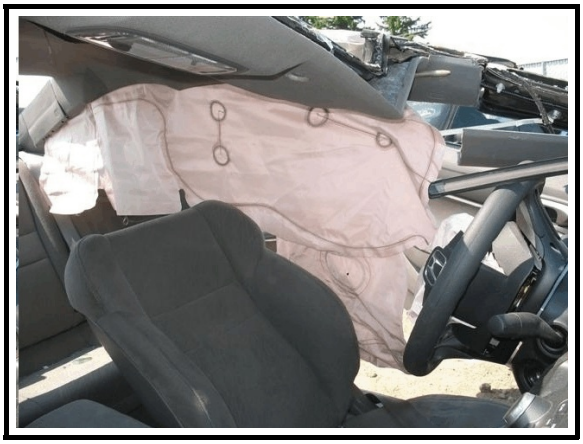

Figure 9. Left side curtain air bag and seat-mounted side air bag

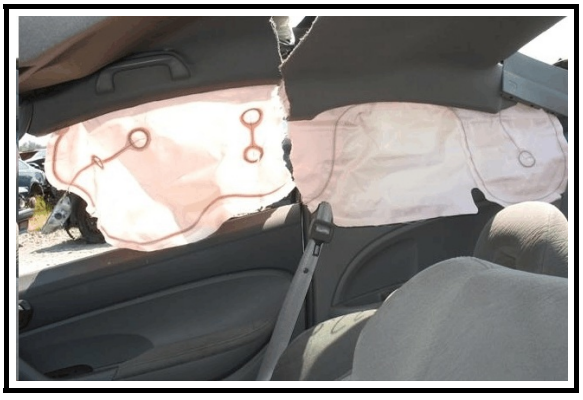

Figure 10. Right side curtain air bag was cut near B-pillar

Rollover

The Honda had a Static Stability Factor (SSF) of 1.44, and a rollover resistance rating of 4 out of 5 stars indicating the vehicle had a 10 percent risk of rollover.[1] The SSF is an at-rest calculation of a vehicle's rollover resistance, based on its track width and center of gravity. A higher SSF value equates to a more stable, less top-heavy vehicle. Most passenger car SSF ratings range from 1.30 - 1.50.

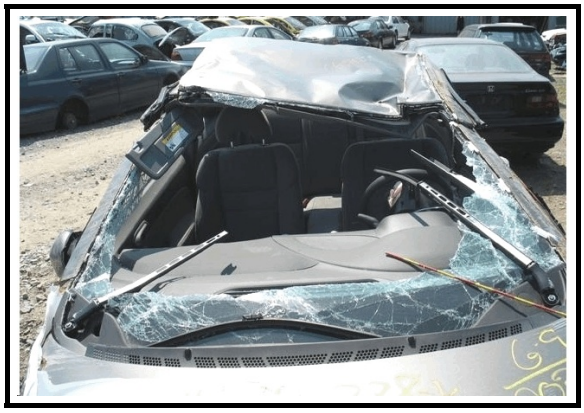

Figure 11. Frontal view showing roof crush sustained during rollover

The vehicle's pre-crash speed and stability were not known. Following the impact with the impact attenuator, the vehicle rotated clockwise 220 degrees, initiated a right side leading turn over, and rolled three quarter-turns (**Figure 11**). It is not known what effect driver input had on the rollover; however, steering and braking forces were mitigated due to the vehicle's rotational forces and the displacement of the right front rim and tire. The vehicle rolled three quarter turns and came to final rest on its left side. The roll distance was not known.

Occupant Demographics

Driver

Age/Sex:	24/Male
Seated Position:	Front left
Height:	Unknown
Weight:	Unknown
Seat Type:	Bucket with folding back
Seat Track Position:	Forward-track
Manual Restraint Usage:	Lap and shoulder belt
Usage Source:	Vehicle inspection
Air bags:	Frontal air bag, seat-mounted side air bag, side curtain air bag, deployed.
Alcohol/Drug Involvement:	None
Type of medical treatment:	Unknown

[1] www.safercar.gov

Occupant Kinematics

Driver

The 24-year-old male driver was seated in an unknown posture and was restrained by the vehicle's 3-point manual lap and shoulder belt. The vehicle drifted off the right edge of the road and impacted the impact attenuator with its front end. This impact displaced the right front rim from the axle, and the vehicle initiated a sharp clockwise rotation. The driver was displaced forward and to the right in response to the direction of force, and he loaded the safety belt. The driver's frontal air bag deployed and he contacted the bag, depositing a fabric transfer.

The vehicle's right rear tire then engaged the roadway inducing a right side leading turn over. During the first quarter turn, the side impact sensors commanded the deployment of the vehicle's side curtain air bags and the driver's seat-mounted side air bag. The driver was displaced to the left in response to the vehicle's clockwise rotation, then was displaced to the right in response to the roll direction. During the third quarter turn he was displaced to the left and was reported by police to have sustained a possible injury to his left arm. The vehicle rolled three quarter turns, during which the driver stayed in his seat due to his safety belt restraint.

The vehicle came to final rest on its left side and facing northwest. It is presumed the driver remained in the vehicle until emergency personnel arrived on-scene, due to the fact that there was significant extrication damage to the vehicle's exterior and interior. The vehicle's passenger compartment did not indicate evidence of mechanical entrapment due to intrusion.

Occupant Injuries

Driver

The driver was reported by police to have sustained a possible arm injury. Efforts to obtain injury data were unsuccessful.

Attachment 1. Scene Diagram