

Electronic Stability Control/Vehicle Rollover
Dynamic Science, Inc./Case Number: DS05026
2005 Acura TSX
California
September 2005

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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.

1. Report No. DS05026	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Electronic Stability Control System Investigation		5. Report Date June 27, 2006		
		6. Performing Organization Report No.		
7. Author(s) Dynamic Science, Inc.		8. Performing Organization Report No.		
9. Performing Organization name and Address Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401		10. Work Unit No. (TRAVIS)		
		11. Contract or Grant no. DTNH22-01-C-27002		
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590		13. Type of report and period Covered [Report Month, Year]		
		14. Sponsoring Agency Code		
15. Supplemental Notes				
16. Abstract This on-site investigation focused on the Electronic Stability Control feature in a 2005 Acura TSX. This single vehicle crash occurred in September 2005 at 0103 hours in an urban area of California. The crash occurred at a three-leg intersection controlled by a large traffic circle located in the center of the two intersecting roadways. The case vehicle is a 2005 Acura TSX being driven by a 23-year-old restrained male. There was one additional occupant in the Acura. The Acura was traveling east in the right lane of a two lane, two way, undivided asphalt roadway and was approaching the intersection controlled by the traffic circle. The driver of the Acura reported that he did not see the traffic circle until it was too late to maneuver around it. The case vehicle continued straight ahead and the left side traveled up and over the raised median located just west of the intersection. The case vehicle sustained a number of impacts before final overturning. The driver sustained minor injuries. The police arrested him at the scene for alcohol related charges, transported him to a hospital for medical clearance and then transported him to jail. Per the driver, he was taken by police to a hospital but he refused medical treatment. The front right occupant complained of neck and back pain and was transported by ambulance to the same hospital where she was treated and released. The vehicle was towed from the scene and was later declared a total loss.				
17. Key Words Air bag, deployment, injury, AOPS, advanced, rollover, electronic stability control		18. Distribution Statement		
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price	

Dynamic Science, Inc.
Crash Investigation
Case Number: DS05026

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BACKGROUND:

Description

This on-site investigation focused on the performance of the Electronic Stability Control feature in a 2005 Acura TSX. The case vehicle comes equipped with Vehicle Stability Assist (VSA), which according to information provided by Acura, “is a system that adds side slip control to anti-lock braking and traction control systems”.

This crash was identified by DSI and assigned as a case by NHTSA on November 29, 2005. DSI obtained permission to inspect the vehicle on December 12, 2005 and received an abbreviated and sanitized copy of the police report on December 15, 2005. Field work was completed on December 17, 2005. Permission to remove the Electronic Data Recorder (EDR) was obtained through the insurance company. Multiple attempts to retrieve the EDR were made, but it was unable to be removed due to its location and the steel components surrounding it.

This single vehicle crash occurred in September 2005 at 0103 hours in an urban area of California. The crash occurred at a three-leg intersection controlled by a large traffic circle located in the center of the two intersecting roadways.



Figure 1. Front end damage - 2005 Acura TSX



Figure 2. Left side rollover damage - 2005 Acura TSX

The case vehicle is a 2005 Acura TSX being driven by a 23-year-old restrained male. There was one additional occupant in the Acura.

The Acura was traveling east in the right lane of a two lane, two way, undivided asphalt roadway and was approaching the intersection controlled by the traffic circle. On the east and west sides of this intersection, just prior to the roundabout, there are raised medians which are intended to route vehicles in the correct travel direction so they can safely maneuver around the traffic calming device.

The driver of the Acura reported that he did not see the traffic circle until it was too late to

maneuver around it. The case vehicle continued straight ahead and the left side traveled up and over the raised median located just west of the intersection. The left front tire rim impacted the bottom section of the yield sign, slightly bending the metal sign post. The Acura continued east and traveled up and over the outer section of the traffic circle. This section is comprised of concrete and has a gradual uphill grade as it gets closer to the inner circle. The Acura traveled up this section of the traffic circle and became airborne. While airborne, the undercarriage struck the inner concrete curb, damaging the left muffler. The vehicle landed in the grassy area in the center of the traffic circle and struck the inner curb with its lower front end, resulting in the deployment of the driver and front right passenger front air bags. The case vehicle then continued east and traveled back onto the roadway before it traveled off the southeast corner of the intersection. The Acura's front end impacted a lamppost, shearing it from its base. The lamppost fell and sections of the post impacted both the left and right A pillars. After striking the lamppost, the Acura TSX continued east and sideswiped an A- frame traffic barricade with its right side. The case vehicle traveled a very short distance east of the barricade and went into a ditch. The height differential and sloped sides of the ditch caused the Acura to roll over one quarter turn to the left. The case vehicle came to final rest laying on its left side in the ditch, facing east.

The driver sustained minor injuries. The police arrested him at the scene for alcohol related charges, transported him to a hospital for medical clearance and then transported him to jail. Per the driver, he was taken by police to a hospital but he refused medical treatment. The front right occupant sustained a C2 spinal fracture, a tongue laceration, and a contusion to the center of her chest. She was transported by ambulance to a local hospital. She arrived with a GCS score of 15. She was treated and released. According to the driver, this occupant had a previous neck injury that was aggravated by this collision.

The vehicle was towed from the scene and was later declared a total loss.

SUMMARY

Crash Site

This single vehicle crash occurred in September 2005 at 0103 hours in an urban area of California. The crash occurred in a three-leg intersection with a large traffic circle in the center. When vehicles enter the roundabout, there is only one travel lane available. This is a one-way lane that flows counterclockwise around the traffic calming device.



Figure 3. Approach of case vehicle to initial roadway departure area - east

The Acura was traveling east in the right lane of an asphalt roadway consisting of two undivided travel lanes. The one eastbound lane is separated from the one westbound lane by painted, yellow, no passing double lane lines. West of the crash area there are dedicated bike lanes adjacent to both travel lanes, but the solid white lines designating the bike lanes are not present in the precrash area. There are no curbs east or west of the intersection, but curbs are present in the immediate area surrounding the traffic circle and roundabout medians. The traffic circle is large and consists of an outer ring of concrete with an uphill grade. The outermost edge of the traffic circle has a height of 5.0 cm (2.0 in). The concrete ring is 3.2 m (10.4 ft) wide and as the outer concrete ring ends, there is a curb measuring 17.0 cm (6.7 in) high and 14.0 cm (5.5 in) wide. The inner section of the traffic circle is an uneven area of grass and dirt measuring 15.1 m (49.5 ft) in diameter. There are raised medians on the east, west and south sides of the traffic circle that help safely route vehicles around the roundabout. Near the southeast corner of the intersection, there is a concrete drainage culvert located off the roadway, next to the eastbound travel lane. The drain consists of a concrete base that is shaped like an ‘H’ and has steel grating in the center. There was no visible damage to the culvert, but a damaged A-frame traffic barricade was found laying on the ground next to the culvert. It is not known why the barricade was there or if it had been moved post-impact. Southeast of the culvert there is a ditch that is approximately 109.0 cm (43.0 in) deep.



Figure 4. Initial roadway departure point and damaged yield sign (east)



Figure 5. Damage to the traffic circle's inner curb (east)



Figure 6. Damage from second curb impact (east)

The posted speed limit for the east/west roadway is 64 km/h (40 mph), but drops to 24 km/h (15 mph) for vehicles traversing the roundabout. At the time of the crash the roadway was dry, there were no adverse weather conditions and no visual obstructions were present. The crash occurred during the early morning hours and although it was dark, there were streetlights illuminating the area. At the intersection, there are yield signs posted for all vehicles entering the roundabout.

Pre-Crash

The case vehicle was a 2005 Acura TSX being driven by a restrained 23-year-old male (191 cm/75 in, 68 kg/150 lbs). There was a restrained 21-year-old female occupant (178 cm/70 in, 64 kg/140 lbs) in the front right seating position.

The crash occurred at a three-leg intersection with a large traffic circle in the center. The Acura was traveling east in lane one of the two lane, two-way roadway and was approaching the roundabout. On the east, west and south sides of this intersection, just prior to the traffic circle, there are raised medians which route vehicles in a counterclockwise direction around the traffic calming device. There are yield signs posted on each of the raised medians.

The Acura TSX was traveling in the right lane and was approaching the intersection controlled by the traffic circle.

Crash

The driver of the Acura reported that he did not see the raised medians or roundabout until it was too late to maneuver around them. There was no evidence of braking. The case vehicle continued straight ahead and the left side traveled up and over the raised median located just west of the intersection. The left front tire rim struck the bottom section of the yield sign, slightly bending the metal sign post. The vehicle continued east and traveled over the outer section of the traffic circle. This section is comprised of concrete and has a gradual uphill grade as it gets closer to the inner section of the roundabout. The Acura traveled up this section of the traffic circle and became airborne. While airborne, the undercarriage struck the inner concrete curb (12UZDW2), damaging both the undercarriage and the curb. This undercarriage impact was not a non-horizontal event. It appears that as the Acura was airborne, the undercarriage scraped the curb and the left muffler snagged on the curb. The vehicle landed in the grassy area in the center of the traffic circle and struck the inner curb with its lower front end (12FDLW2) resulting in the deployment of the driver and passenger front air bags. This impact dislodged a 1.2 m (3.9 ft) section of the curb and pieces of concrete were found on the southeast corner of the intersection. The case vehicle then continued east and traveled back onto the roadway before it traveled off the southeast corner of the intersection. The Acura's front end impacted a lamppost (12FYEN2), shearing it from its base.



Figure 7. Pole sheared from its base



Figure 8. Case vehicle's path to ditch and rollover location

The barrier routine of the WinSmash program computed a total delta V of 27.0 km/h (16.8 mph)¹. The longitudinal and lateral components were -27.0 km/h (-16.8 mph) and 0.0 km/h (0.0 mph) respectively. The calculated barrier equivalent speed was 27.0 km/h (16.8 mph).

The lamppost fell and sections of the post impacted both the left and right A pillars (00TYDW4). The lamppost had been removed from the crash scene and was not available for inspection. After striking the lamppost, the Acura continued east and sideswiped an A-frame traffic barricade with its right side (12RYES1). The case vehicle traveled a very short distance east of the barricade and went into a ditch. The height differential and sloped sides of the ditch caused the Acura to roll over (00LDAO2) one quarter turn to the left.

The case vehicle came to final rest laying on its left side, off the roadway, facing east.

The front right passenger's seat back mounted side air bag also deployed during the crash, but it is not known which event triggered its deployment. The driver's seat back mounted side air bag did not deploy during the crash.



Figure 9. Ditch - Final rest location of case vehicle (east)

¹This impact was out of scope for the WinSmash program because the pole was a yielding object and is provided for informational purposes only.

Post-Crash

The driver sustained minor injuries, consisting of a sore left shoulder and superficial cuts to the knuckles on his right hand. The police arrested him at the scene, transported him to a hospital for medical clearance and then transported him to jail. The driver arrived at the hospital with a Glasgow Coma Scale (GCS) score of 15. He was examined and then released.

The front right occupant sustained a C2 spinal fracture, a tongue laceration, and a contusion to the center of her chest. She was transported by ambulance to a local hospital. She arrived with a GCS score of 15. She was treated and released. According to the driver, this occupant had a previous neck injury that was aggravated by this collision.

The vehicle was towed from the scene and was later declared a total loss.

Vehicle Data - 2005 Acura TSX

The 2005 Acura TSX was identified by the Vehicle Identification Number (VIN): JH4CL96985Cxxxxxx. The Acura TSX is a four door sedan, front wheel drive passenger vehicle with seating for five. It was equipped with a 2.4 liter 4-cylinder engine, 5 speed semi-automatic transmission, four wheel anti-lock front and rear disc brakes, stability control and electronic traction control via ABS and engine management, and a tilt and telescoping steering wheel. The vehicle mileage could not be obtained from the digital odometer because the vehicle had no power. The driver estimated the mileage at the time of the crash to be approximately 4,828 km (3,000 miles).

The 2005 Acura TSX comes equipped with Vehicle Stability Assist (VSA), which according to information provided by Acura, “is a system that adds side slip control to anti-lock braking and traction control systems”. VSA is intended to help control sudden changes in vehicle behavior, which then gives the driver more time to keep control of the situation. According to Acura, when a VSA equipped vehicle is traveling on wet and/or icy roadways, VSA will help stabilize the vehicle, “reducing counter-productive driver tension”.

The 2005 Acura TSX was equipped with Michelin Pilot HX MXM4 Radial XSE P215/50R17 tires. The manufacturer recommended cold tire pressure was 221 kPa (32 psi) for the front and 207 kPa (30 psi) for the rear. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Flat	7 mm (9/32 in)	Yes	Rim bent
LR	Flat	7 mm (9/32 in)	No	Torn
RR	Flat	7 mm (9/32 in)	No	Rim damaged
RF	Flat	7 mm (9/32 in)	Yes	Torn, rim damaged

The front row seating in the 2005 Acura TSX was configured with dual leather bucket seats with adjustable head restraints that were not damaged. The driver's seat back angle was 110 degrees and the seat cushion angle was 15 degrees. The front right passengers's seat back angle was 105 degrees and the seat cushion angle was 12 degrees. The second row was configured as a leather 60/40 split bench seat with folding backs. The two outboard second row seating positions were equipped with adjustable head restraints that were not damaged. The second row bench seat back angle was 106 degrees and the seat cushion angle was 8 degrees.

Vehicle Damage

Exterior Damage - 2005 Acura TSX

Damage Description: The 2005 Acura TSX sustained light undercarriage damage as a result of the first impact with the west side of the traffic circle's inner curb. There was very little damage other than sporadic undercarriage scrapes and damage to the left muffler, which appears to have snagged on the curb. The case vehicle sustained moderate front end damage as a result of the impact with the east side of the traffic circle's inner curb and the lamppost. The location and width of the direct damage could not be determined because the front bumper cover was not with the vehicle and there was overlapping front end damage from other crash events. The direct damage from the curb impact was low on the vehicle, mainly to the lower portion of the front bumper and below. The direct damage from the impact with the lamppost began near the centerpoint of the vehicle, and extended to the left. Six crush measurements were documented along the damaged front bumper as follows: C1=0.0 cm (0.0 in), C2=23.0 cm (9.1 in), C3=18.0 cm (7.1 in), C4=15.0 cm (5.9 in), C5=14.0 cm (5.5 in), C6=8.0 cm (3.1 in). An additional max crush measurement was taken 26.0 cm (10.2 in) left of the post-crash centerpoint. There was 27.0 cm (10.6 in) of longitudinal crush in this location. In order to calculate the correct amount of crush to the front bumper, freespace measurements were obtained from an exemplar vehicle. When the lamppost sheared from its base, it fell on top of the Acura and impacted both the left and right A pillars. The windshield header near the right A pillar was also damaged.

The Acura sustained moderate right side damage as a result of sideswiping the A-frame traffic barricade. The direct damage began 162.0 cm (63.8 in) forward of the right rear axle and extended up the right side 182.0 cm (71.7 in).

The case vehicle sustained moderate left side damage as a result of the rollover event. There was 15.0 cm (5.9 in) of lateral crush at the max crush location, 291.0 cm (114.6 in) forward of the left rear axle. There was no vertical crush as a result of the rollover.

CDC	(Impact 1):	12F9999
	(Impact 2):	12UZDW2
	(Impact 3):	12FDLW2
	(Impact 4):	12FYEN2
	(Impact 5):	00TYDW4
	(Impact 6):	12RYES1
	(Impact 7):	00LDAO2

Delta V (Impact 4) ² :	Total	27.0 km/h (16.8 mph)
	Longitudinal	-27.0 km/h (-16.8 mph)
	Latitudinal	0.0 km/h (0.0 mph)
	Barrier Equivalent Speed	27.0 km/h (16.8 mph)
	Energy	45,732 joules (33,730 ft lbs)



Figure 10. Front crush profile



Figure 11. Back/right and muffler damage from undercarriage impact



Figure 12. Damaged left muffler

²This is an out of scope run and the data is being provided for informational purposes only.

Interior Damage - 2005 Acura TSX

The case vehicle sustained moderate interior damage due to intrusion, occupant contacts and normal air bag deployment related damage.

There were scuffs to the shoulder portions of the driver and front right passenger seat belts. The front right passenger's B pillar seat belt pretensioner actuated and the belt was found still locked in place post-crash. The driver's seat belt exhibited signs of being used during the crash but the pretensioner did not actuate.

One of the right side steering column control levers was broken off, likely due to driver contact. There were signs of occupant contact to the glove compartment door, possibly from the passenger's lower left leg.

There was no integrity loss and all four doors remained closed and operational. The windshield was cracked and in place post crash. There was a narrow 35.0 cm (13.8 in) long windshield seam separation at the left A pillar. This was a result of the lamppost falling onto the vehicle. The opening was not wide enough to be considered integrity loss.

There was vertical windshield, windshield header and A pillar intrusion. The cover of the left A pillar intruded laterally and there was very slight lateral intrusion of the right front roof side rail. An exemplar vehicle was located in order to obtain comparative, undamaged measurements and the specific passenger compartment intrusions were documented as follows:



Figure 13. Left front rollover damage and left A pillar damage



Figure 14. Closer view - Left A pillar damage



Figure 15. Windshield and left A pillar intrusion

Row/Position	Intruded Component	Magnitude of Intrusion	Direction
1L	A pillar	9.0 cm (3.5 in)	Vertical
1L	Windshield	9.0 cm (3.5 in)	Vertical
1C	Windshield	8.0 cm (3.1 in)	Vertical
1L	A pillar cover	7.0 cm (2.8 in)	Lateral
1R	A pillar	5.0 cm (2.0 in)	Vertical
1R	Windshield header	4.0 cm (1.6 in)	Vertical
1R	Windshield	4.0 cm (1.6 in)	Vertical
1R	Roof side rail	3.0 cm (1.2 in)	Lateral

Manual Restraint System - 2005 Acura TSX

The 2005 Acura TSX was configured with manual 3-point lap and shoulder belts for each of the five seating positions. Both front seat belts were equipped with load limiters, B-pillar retractor pretensioners and seat belt height adjusters. The driver's pretensioner did not actuate during the crash but the front right passenger's did. Both front row seat belt height adjusters were in the full up position. The driver's safety belt was configured with a sliding latch plate and an emergency locking retractor (ELR). The right front safety belt had a sliding latch plate but the retractor type could not be determined at the inspection because the seat belt was locked in place post-crash. An exemplar vehicle was inspected to determine the front right passenger belt retractor type, and it was determined to be a switchable ELR/Automatic Locking Retractor. All three second row seat belts had sliding latch plates and switchable retractors.

The second row outboard seating positions were equipped with the lower anchor points that are part of this vehicle's Lower Anchors and Tethers for Children (LATCH) system. The three rear seat positions were equipped with child safety top tether strap anchor points, located directly behind the second row seat backs.

Supplemental Restraint System - 2005 Acura TSX

The case vehicle was equipped with advanced occupant protection systems. The systems consist of the driver and front right passenger dual stage, dual threshold front air bags, driver and front right passenger side air bags, a front passenger Occupant Position Detection System, and side curtain air bags that extend from the A pillars to the C pillars.

The air bag systems are controlled by a module whose primary function is to control the deployment of the occupant protection systems. The insurance company gave permission to remove the module from this vehicle, and multiple attempts were made to harvest it, but it could not be removed due to accessibility issues.

The vehicle was also equipped with front row driver and passenger B pillar seat belt retractor pretensioners. Both belts showed signs of occupant loading, demonstrating that they were being worn during the crash. As a result of the longitudinal deceleration that occurred during the collision events, the driver and front right passenger air bags deployed, and the front right passenger seat belt pretensioner activated. The driver's seat belt pretensioner did not activate. The driver reported during the interview that his seat belt held him in place and performed well during the crash.

The driver's air bag was mounted in the center of the steering wheel hub. The air bag module cover flaps had a general H configuration with a few additional cutouts. The top cover flap measurements were as follows: the upper and lower flap edges were 13.5 cm (5.3 in) wide and both side flap edges were 5.0 cm (2.0 in) high. The bottom cover flap measurements were as follows: the upper flap edge was 13.5 cm (5.3 in) wide and the lower flap edge was 7.5 cm (3.0 in) wide. The sides of the bottom cover flap were faceted with the upper facet measuring 3.0 cm (1.2 in) and the lower facet measuring 6.0 cm (2.4 in). The air bag was circular in shape and measured 60.0 cm (23.6 in) high/wide in its deflated state with an excursion of 28.0 cm (11.0 in)



Figure 16. Driver's front air bag; arrows point to top of bag (upside down in photo)



Figure 17. Front right passenger air bag

from the module face. The longitudinal distance between the module face and the front left seat back was 72.0 cm (28.3 in). The air bag had two internal tethers and two circular vent ports on the back of the bag at the 10 and 2 o'clock positions. There were no visible signs of occupant contact or damage to the front or back of the driver air bag.

The front right passenger air bag was a top instrument panel mount. The air bag module cover flaps had an H configuration. The top and bottom cover flaps measured 24.0 cm (9.4 in) wide, with the height of the top flap measuring 5.0 cm (2.0 in) and the height of the bottom flap measuring 6.0 cm (2.4 in). The air bag had a diamond shape, with the top section measuring 48.0 cm (18.9 in) seam to seam laterally and the bottom section measuring 15.0 cm (5.9 in) laterally in its deflated state. The bag was 55.0 cm (21.7 in) high. In its deflated state, the maximum excursion was 73.0 cm (28.7 in) from the module face. The longitudinal distance between the module face and the front right seat back was 105.0 cm (41.3 in). There were two circular vent ports on the sides of the air bag at the 3 and 9 o'clock positions. There was no damage to the cover flaps or air bag. There was a light yellow discoloration found in the lower center section of the bag that matched yellow discolorations found near the cover flaps. It is likely these were from the deployment and not from occupant contact.

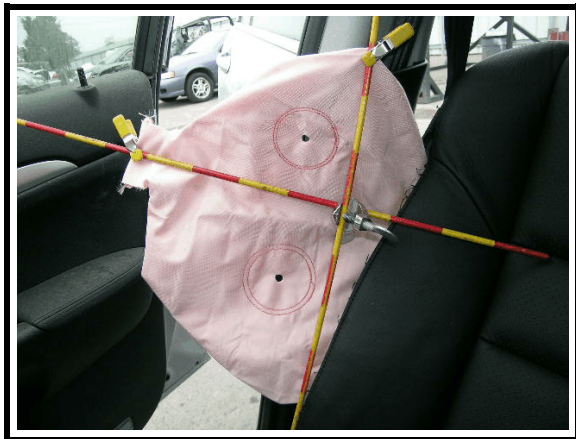


Figure 18. Front right passenger side air bag

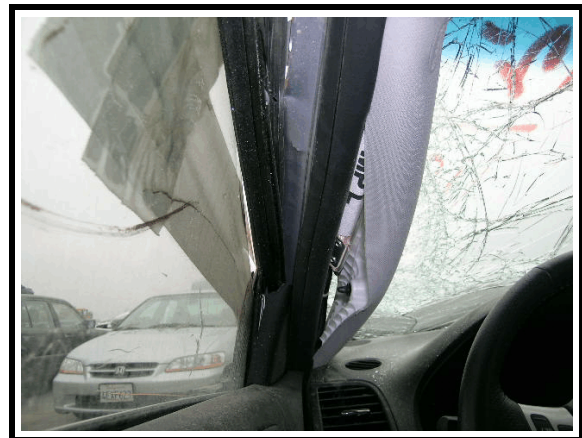


Figure 19. Deformed/Intruded left A pillar



Figure 20. Right side curtain air bag

The front right seat back mounted side air bag deployed during the collision, but it is not known which crash event triggered the deployment. The driver's side air bag did not deploy. The air bag module cover flap was rectangular in shape and measured 8.0 cm (3.1 in) wide and 22.0 cm (8.7 in) high. The deployed side air bag was semi-circular in shape with a height of 28.0 cm (11.0 in) and an excursion of 30.0 cm (11.8 in) in its deflated state. It had no tethers. There was one vent opening located at the 9 o'clock position as viewed from the left side of the bag. There were no visible signs of occupant contact or damage to the side air bag. There were black deployment transfers found in the inner upper right quadrant and faint yellowish streaks found on the outside lower right quadrant.

The right side curtain deployed during the collision, but it is not known which crash event triggered the deployment. The left side curtain did not deploy. Both A pillars were damaged during the non-horizontal pole impact. It appears that when the case vehicle struck the lamppost with its front end, the post sheared from its base and fell on top of the Acura as the vehicle continued traveling east. Part of the post impacted the middle of the left A pillar, deforming and intruding the pillar, and possibly damaging a portion of the left side curtain air bag module. The lamppost also impacted the top of the right A pillar, but this non-horizontal impact resulted in less passenger compartment intrusion and A pillar damage. The deployed right side curtain air bag extended from the A to the C pillar. There was a small coverage gap present at the A pillar. The gap consisted of a triangular shaped area measuring 15.0 cm (5.9 in) in height at the forward aspect of the bag, 35.0 cm (13.8 in) in width along the belt line and 25.0 cm (9.8 in) in length along the A-pillar. The side curtain was rectangular in shape and in its deflated state, measured 158.0 cm (62.2 in) in length. The height of the front section of the curtain measured 45.0 cm (17.7 in) and the back section measured 40.0 cm (15.7 in). The air bag had one external tether, located at the front of the bag at the A pillar. At the inspection, the tethered section was found still tucked under the right A pillar cover. When the side curtain was pulled out to expose the tether, the coverage gap at the A pillar decreased in size. There were no vent ports. The side curtain deployed from the A pillar and right roof side rail cladding. In the front right passenger's seating area, there were two small blood stains found on the lower portion of the outer curtain that were likely due to post-crash movement of this occupant inside the vehicle. There were no visible signs of damage to the side curtain.



Figure 21. Gap distance at Right A pillar as found at the inspection



Figure 22. Gap distance after tether pulled out of the A pillar cover

Occupant Demographics - 2005 Acura TSX

	Driver	Occupant 2
Age/Sex:	23/Male	21/Female
Seated Position:	Front left	Front right
Seat Type:	Leather covered bucket seat	Leather covered bucket seat
Height:	191 cm (75 in)	178 cm (70 in)
Weight:	68 kg (150 lb)	64 kg (140 lb)
Occupation:	Consultant	Not Applicable
Pre-existing Medical Condition:	None	Previous neck injury that was aggravated by this crash
Alcohol/Drug Involvement:	Had been drinking; BAC unknown	Had been drinking; BAC unknown
Driving Experience:	7 years	Not Applicable
Body Posture:	Sitting upright, forward facing	Sitting upright, forward facing
Hand Position:	Left hand on steering wheel near 12 o'clock position; Right hand resting on center console	Both hands may have been in her lap but may have had left hand resting on the center console
Foot Position:	Left foot on floorboard Right foot on the accelerator	Both feet on floorboards
Restraint Usage:	Manual lap and shoulder belt available, used	Manual lap and shoulder belt available, used
Clothing Worn:	Jeans and a cotton white and blue polo style shirt	Jeans and a pink satin shirt
Eyeglasses/Contacts:	None	Glasses; not damaged/did not cause injury to this occupant.
Air bag:	Front air bag available-deployed. Seat back mounted side air bag available-did not deploy. Side curtain available-did not deploy.	Front air bag available-deployed. Seat back mounted side air bag available-deployed. Side curtain available-deployed.

Occupant Injuries - 2005 Acura TSX

Driver: Injuries obtained from the driver interview and official medical records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Lacerations to knuckle	790600.1,1	Glass	Possible
Sore shoulder (not codeable)			

Front Right Occupant: Injuries obtained from emergency room records, radiology reports, and interview.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Contusion, chest (central)	490402.1,4	Seat belt webbing	Probable
Tongue laceration	243204.1,8	Impact forces	Probable
C2 spinal fracture	650216.2,6	Impact forces	Possible

Occupant Kinematics - 2005 Acura TSX

Driver Kinematics

The male driver of the case vehicle was seated upright in the leather covered bucket seat and was restrained by the 3-point manual lap and shoulder belt. The shoulder belt anchorage adjustment was in the full up position. The seat was adjusted to between the middle and rearmost track position. The seat back was reclined at a 110 degree angle and the seat bottom had a 15 degree angle.

Just prior to the first crash event, the Acura departed the roadway and ramped up the sloped traffic circle, causing the vehicle to become airborne. The undercarriage of the Acura impacted the inner curb of the traffic circle, damaging the undercarriage and left muffler. Since this was a low delta V event, it is likely that the driver remained in position. The Acura landed in the grassy area in the center of the traffic circle and struck the inner curb with its lower front end, resulting in the deployment of the driver's front air bag. This impact caused the male driver to load his seat belt as he initiated a forward trajectory towards the 12 o'clock direction of force. The driver's seat belt retractor pretensioner did not actuate. The case vehicle continued east and traveled back onto the roadway. The Acura traveled a short distance before it departed the roadway to the right. As the front of the Acura impacted a lamppost, the driver initiated a forward trajectory towards the 12 o'clock direction of force, striking a steering column mounted control lever with his right hand. The driver's seat belt pretensioner also did not actuate during

this event. The lamppost sheared from its base and impacted both A pillars. The Acura continued east and the right side sideswiped a traffic barricade. This was also a low delta V event and the driver likely remained in position. The Acura continued a short distance further and traveled into a ditch, causing the vehicle to rollover. As the Acura rolled one quarter turn to the left, the driver initiated a lateral trajectory towards the left door and roof side rail. Although no visible occupant contact evidence was found, it is likely the driver contacted the door panel. The case vehicle came to final rest laying on its left side in the ditch, facing east.

This occupant sustained minor injuries and was able to exit the vehicle on his own. He sustained minor injuries, consisting of a sore left shoulder and superficial cuts to the knuckles on his right hand. The police arrested him at the scene, transported him to a hospital for medical clearance and then transported him to jail.

Front Right Occupant Kinematics

The 21-year-old front right female passenger was seated upright in the leather covered bucket seat and was restrained by the 3-point manual lap and shoulder belt. The shoulder belt anchorage adjustment was in the full up position. The seat was adjusted to between the middle and rearmost track position. The seat back was reclined at a 105 degree angle and the seat bottom had a 12 degree angle. Just prior to the first crash event, the Acura departed the roadway and ramped up the sloped traffic circle, causing the vehicle to become airborne. The undercarriage of the Acura scraped along the inner curb of the traffic circle, but since it was a low delta V event, it is likely that this passenger remained in position. The Acura landed in the grassy area in the center of the traffic circle and struck the inner curb with its lower front end, causing the female passenger to initiate a forward trajectory towards the 12 o'clock direction of force. The passenger's seat belt pretensioner actuated and her front air bag deployed. The case vehicle continued east and traveled back onto the roadway. The Acura traveled a short distance



Figure 23. Broken steering column control lever



Figure 24. Deformed center console



Figure 25. Evidence of loading to the right front passenger's seat belt

before it departed the roadway to the right. As the front of the Acura impacted the lamppost, this passenger initiated a slight forward trajectory towards the 12 o'clock direction of force, but was likely held in position by her seat belt. The lamppost sheared from its base and impacted both A pillars. The Acura continued east and the right side sideswiped a traffic barricade. This was also a low delta V event and the passenger likely remained in position. The Acura continued a short distance further and traveled into a ditch, causing the vehicle to rollover. As the Acura rolled one quarter turn to the left, this passenger initiated a lateral trajectory to her left and contacted the center console, deforming it (Figure 24). The case vehicle came to final rest laying on its left side in the ditch, facing east. This occupant's neck injury and tongue laceration appears to have occurred as a result of the impacts throughout this long crash sequence. The chest contusion was a result of loading to the torso portion of the lap and shoulder belt (Figure 25).

This occupant was assisted out of the vehicle by several people who had stopped at the scene. The front right occupant sustained a C2 spinal fracture, a tongue laceration, and a contusion to the center of her chest. She was transported by ambulance to a local hospital. She arrived with a GCS score of 15. She was treated and released. According to the driver, this occupant had a previous neck injury that was aggravated by this collision.

Attachment 1. Scene Diagram

