

Rollover Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS07026
2006 Toyota RAV4
Washington
May 2007

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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 a 2006 Toyota RAV4 that was involved in a rollover crash. This single vehicle crash occurred in May 2007 at 2244 hours. The crash occurred on an undivided city street in the state of Washington. The case vehicle was being driven by a restrained 43-year-old male. The Toyota RAV4 was traveling northbound at an unknown speed. The driver of the Toyota lost control and the left front of the vehicle struck a parked vehicle. It appears that the Toyota rotated in a counterclockwise direction and then overturned onto its roof. The driver of the Toyota was arrested for driving while intoxicated. There were no reported injuries. The Toyota was towed due to damage and was later declared a total loss by the insurance company.			
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BACKGROUND

This on site investigation focused on a 2006 Toyota RAV4 that was involved in a rollover crash (**Figure 1**). This single vehicle crash occurred in May 2007 at 2244 hours. The crash occurred on an undivided city street in the state of Washington. The Toyota was being driven by a restrained 43-year-old male. The Toyota was traveling northbound at an unknown speed. The driver of the Toyota lost control and the left front of the vehicle struck a parked vehicle. It appears that the Toyota rotated in a counterclockwise direction and then overturned onto its roof. The driver of the Toyota was arrested for driving while intoxicated. There were no reported injuries. The Toyota was towed due to damage and was later declared a total loss by the insurance company.



Figure 1. 2006 Toyota RAV4

This rollover investigation was identified by NHTSA during a review of police reports. DSI was faxed the police report on June 26, 2007 with instructions to locate the case vehicle. DSI located the subject vehicle and obtained permission to inspect the vehicle on June 30, 2007. Field work was completed on July 2, 2007.

SUMMARY

Crash Site

This single vehicle crash occurred on a two-lane, two-way urban street in May 2007 (**Figure 2**). At the time of the crash, there were no adverse weather conditions and the concrete roadway surface was dry. There is a 2% uphill grade for northbound travel. It was dark at the time of the crash and the streetlights were on. Parking is allowed on both sides of the street and vehicles were parked facing both north and south on both sides of the street. The roadway is narrow. When there are vehicles parked on both sides of the street there is only enough room for a single vehicle to travel north/south. A 2001 Jaguar S-type four-door sedan (**Figure 3**, exemplar view) was parked on the west side of the roadway facing south. The speed limit at this location is 40 km/h (25 mph).



Figure 2. Approach to area of impact (north)

Pre-Crash

The 2006 Toyota RAV4 was traveling northbound at what police termed a “high rate of speed”.

Crash

The driver of the RAV4 lost control and the left front of the Toyota struck the parked Jaguar. The missing vehicle routine of the WinSmash program computed a total delta V of 9.0 km/h (5.6 mph)¹. The longitudinal and lateral components were -9.0 km/h (-5.6 mph) and 0 km/h (0 mph), respectively.

The RAV4 rotated in a counterclockwise direction and then overturned onto its roof, where it came to rest facing northwest.



Figure 3. Exemplar 2001 Jaguar S-type

Post-Crash

The driver of the Toyota was arrested for driving while intoxicated. There were no reported injuries. The Toyota was towed due to damage and was later declared a total loss by the insurance company.

VEHICLE DATA - 2006 Toyota RAV4

The 2006 Toyota RAV4 Sport was identified by the Vehicle Identification Number (VIN):JTMBK32V265xxxxxx. The Toyota RAV4 was four-door sport utility vehicle that was equipped with a 3.5 liter, six cylinder engine, four-wheel drive, and an automatic transmission. The RAV4 comes standard with the Star Safety System, which includes vehicle stability control (VSC), Traction Control (TRAC), anti-lock brakes (ABS) with Electronic Brake-force Distribution (EBD) and Brake Assist (BA). The RAV4 had a static stability factor of 1.21 with a 17% chance of rollover. The RAV4 was configured with Bridgestone Dueler H/T 235/55R18 tires. The vehicle manufacturer’s recommended tire pressure was 221 kPa (32 psi). The tire manufacturer’s maximum tire pressure was 303 kPa (44 psi). The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	186 kPa (27 psi)	6 mm (8/32 in)	Yes	None
LR	207 kPa (30 psi)	8 mm (10/32 in)	No	None
RR	193 kPa (28 psi)	9 mm (11/32 in)	No	None

¹Calculated using stiffness values derived from NCAP test #5611

RF	138 kPa (20 psi)	6 mm (8/32 in)	No	None
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The seating in the Toyota RAV4 was configured with fabric covered front bucket seats with adjustable head restraints and a fabric covered rear 60/40 split bench rear seat with adjustable head restraints for each seat position. The driver's seat was adjusted to the fully rearward track position. The driver's seat back was at 16 degree angle from vertical and the seat cushion was at a 12 degree angle from the horizontal. The front right passenger's seat back was at 15 degree angle from vertical and the seat cushion was at a 12 degree angle from the horizontal. The rear seat back was at 25 degree angle from vertical and the seat bottom was at an 11 degree angle from horizontal.

Vehicle Damage

Exterior Damage -2006 Toyota RAV4

The 2006 Toyota RAV4 sustained minor front end damage as a result of the impact with the parked Jaguar. The direct damage began at the front left bumper corner and extended laterally 15.0 cm (5.9 in) to the right along the front plane (**Figures 4-5**). The maximum crush along the bumper was at C1 and measured 3 cm (1.2 in). The direct contact extended down the side plane for 45 cm (17.7 in). The direct contact extended into the left front wheel. The wheel was displaced rearward and was restricted. The left wheelbase was reduced by 9 cm (3.5 in). Six crush measurements were documented at the bumper level as follows: C1= 3 cm (1.2 in), C2 = 3 cm (1.2 in), C3 = 0 cm, C4 = 0 cm, C5 = 0 cm, C6 = 0 cm. The Collision Deformation Classification (CDC) for the impact with the parked vehicle was 12FLEE3.



Figure 4. 2006 Toyota RAV4



Figure 5. Left front damage

The RAV4 sustained moderate top and left side damage as a result of the rollover (**Figures 6-7**). The damage on the right side began near the right front bumper corner and extended rearward 377 cm (184.4 in). The damage on the top began at the hood line. It was 157 cm (61.8 in) wide and extended down the hood for 67 cm (26.4 in). The direct damage began again 42 cm (16.5 in) forward of windshield header and extended rearward 98 cm (38.6 in) onto the roof and cargo carrier. The maximum crush was located at the right A pillar (**Figure 8**) and measured 2.5 cm (1.0 in). The CDC for the rollover was 00TYDO2.

All the doors remained closed and operational. The windshield was damaged during the rollover. The right front side glass disintegrated during the rollover.



Figure 6. Right side rollover damage

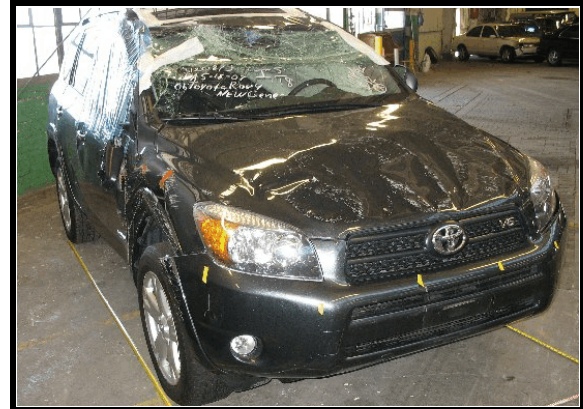


Figure 7. Overview of right side and roof rollover damage



Figure 8. Maximum crush at right A pillar area

Interior Damage -2006 Toyota RAV4

The 2006 Toyota RAV4 sustained minor intrusions along the right roof rail and across the windshield. The right front side glass disintegrated. All the doors remained closed and operational. The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
1R	Roof side rail	2 cm (0.8 in)	Vertical
1R	Windshield	3 cm (1.2 in)	Vertical
1L	Windshield	1 cm (0.4 in)	Vertical

Manual Restraints - 2006 Toyota RAV4

The 2006 Toyota RAV4 was configured with 3-point manual lap and shoulder belts for each seating position. Both front seat safety belts were equipped with retractor pretensioners and adjustable D rings. The driver's adjustable D ring was in the full up position, the front right passenger's was in the mid position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). At the time of the vehicle inspection, the driver's retractor was restricted in the used position as a result of pretensioner actuation. The driver's belt showed evidence of loading (**Figure 9**).



Figure 9. Load marks to driver's seat belt webbing

The remaining outboard safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). The second row middle safety belt was configured with a sliding latch plate and an ELR retractor.

The RAV4 was equipped with LATCH anchors and tether anchors for the two rear outboard seat positions.

Supplemental Restraint Systems -2006 Toyota RAV4

The 2006 Toyota RAV4 was equipped with dual stage frontal air bags, seat back mounted side air bags, and front- and second-row roll-sensing side rollover curtain air bags. The vehicle was also equipped with front seat belt pretensioners. The pretensioners will actuate in the event of a severe frontal impact or, if the vehicle is equipped with side curtain air bags, in the event of vehicle rollover.



Figure 10. Driver's side curtain

The left and right side curtain air bags deployed from the roof cladding during the rollover event (**Figures 10-11**). The side curtains each measured 195 cm (75.8 in) wide by 59 cm (23.2 in) high. The curtain extends 24 cm (9.4 in) below the side glass frame and extended 27 cm (10.6 in) beyond the C pillar. The curtain was tethered to the A pillar by a 12 cm (4.7 in) strap and to the D pillar by a 20 cm (7.9 in) strap. There was no damage to the side curtains and no indications of occupant contact.

The driver's seat belt pretensioner actuated during the rollover event. The front right passenger's pretensioner did not actuate. It is designed not actuate if no passenger is detected.

Rollover Dynamics

The 2006 Toyota RAV4 comes standard with the Star Safety System, which includes vehicle stability control (VSC), Traction Control (TRAC), anti-lock brakes (ABS) with Electronic Brake-force Distribution (EBD) and Brake Assist (BA). The RAV4 had a static stability factor of 1.21 with a 17% chance of rollover. VSC is designed to prevent front-wheel slip and rear-wheel slip. The 2006 Toyota RAV4 was traveling at what police termed a “high rate of speed”. It does not appear that the driver of the RAV4 took any avoidance maneuvers prior to the impact with the parked Jaguar. There were no indications of braking and, based on the direction of force, the RAV4 was tracking at impact. It appears that the stability features did not come into play prior to the initial impact. As the left front of the RAV4 struck the parked Jaguar, the RAV4 rotated sharply in a counterclockwise direction. Due to the rapid rotation, the stability features would not have had any effect. The RAV4 rotated approximately 80 degrees before tripping. The RAV4 tripped and began a right side leading rollover along its longitudinal axis. The RAV4 rolled onto its right side and then onto its roof. The side air curtains deployed and the driver’s seat belt pretensioner actuated during the rollover event. The RAV4 came to rest on its roof. The restrained driver remained generally in place throughout the rollover. There were no indications of contact to the air bags or injuries to this occupant. There were no reported injuries.



Figure 11. Front right passenger side air curtain

OCCUPANT DEMOGRAPHICS - 2006 Toyota RAV4

	Driver
Age/Sex:	43/Male
Seated Position:	Front left
Seat Type:	Bucket
Height:	160 cm (63 in)
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	Alcohol involved. Driver arrested.
Driving Experience:	Unknown
Body Posture:	Upright
Hand Position:	Unknown

Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, used.
Air bag:	Driver's air bag available, did not deploy. Side curtain available, deployed.

OCCUPANT INJURIES - 2006 Toyota RAV4

Driver: Not injured.

OCCUPANT KINEMATICS - 2006 Toyota RAV4

Driver Kinematics

The 43-year-old male driver was seated generally upright and was restrained by the 3-point manual lap and shoulder belt. The seat was adjusted to the rearmost track position. The driver's seat back was at 16 degree angle from vertical and the seat cushion was at a 12 degree angle from the horizontal. It has been reported that the driver had been drinking. At impact with the parked vehicle, the male driver initiated a forward trajectory and loaded the safety belt to some extent. The RAV4 began a counterclockwise rotation and tripped on its right side and then onto its roof. The front- and second-row side curtain air bags deployed and the driver's seat belt pretensioner actuated at this time. The restrained driver remained generally in place throughout the rollover. There were no indications of contact to the air bags or injuries to this occupant.

Attachment 1. Scene Diagram

