

**TRANSPORTATION SCIENCES  
CRASH DATA RESEARCH CENTER**

**Veridian Engineering  
Buffalo, New York 14225**

**ALLEGED SEAT BELT FAILURE INVESTIGATION**

**VERIDIAN CASE NO. CA01-031**

**VEHICLE: 2001 TOYOTA RAV4**

**LOCATION: FLORIDA**

**CRASH DATE: MAY 2001**

**Contract No. DTNH22-94-07058**

**Prepared for:**

**U.S. Department of Transportation  
National Highway Traffic Safety Administration  
Washington, DC 20590**

## **DISCLAIMER**

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness of the involved vehicle(s) or their safety systems.

## TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. <i>Report No.</i> CA01-031</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>5. <i>Title and Subtitle</i> Alleged Seat Belt Failure Investigation Vehicle: 2001 Toyota Rav4 Location: Florida</p>		<p>4. <i>Weights</i></p>	
		<p>6. <i>Report Date:</i> July 2001</p>	
<p>8. <i>Author(s)</i> Crash Data Research Center</p>		<p>7. <i>Performing Organization Code</i></p>	
		<p>9. <i>Performing Organization Report No.</i></p>	
<p>10. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225</p>		<p>11. <i>Work Unit No.</i> CO1115.0358.(0000-9999)</p>	
		<p>12. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>13. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590</p>		<p>14. <i>Type of Report and Period Covered</i> Technical Report Crash Date: May 2001</p>	
		<p>15. <i>Sponsoring Agency Code</i></p>	
<p>16. <i>Supplementary Notes:</i> On-site investigation of the potential failure of the right front manual restraint in a 2001 Toyota Rav4.</p>			
<p>17. <i>Abstract</i></p> <p>This investigation focused on the potential failure of the front right manual restraint in a 2001 Toyota Rav4 sport utility vehicle. The front manual restraint system consisted of a 3-point lap and shoulder belts with retractor-pretensioners for the driver and front right passenger. The vehicle was also equipped with a front Supplemental Restraint System that consisted of driver and front right passenger air bags. The retractor-pretensioners and frontal air bags deployed as a result of an L-configuration crash with a 1991 Ford Thunderbird. The front right restraint allegedly failed to properly restrain the 30 year old female passenger during the crash sequence. The front right passenger sustained a right 4<sup>th</sup> rib fracture, right toe fracture, forehead contusion, right thumb sprain, abdominal contusion and cervical strain as a result of the crash. The driver sustained an abrasion to his left forearm. The driver and front passenger of the Ford were reportedly not injured.</p> <p>The Toyota's female passenger contacted the National Highway Traffic Safety Administration's (NHTSA) Office of Defects Investigations (ODI) regarding the incident. The Office of Defects Investigations requested the Crash Investigations Division assign an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering. The vehicle was located at an automotive dealership and was inspected on May 29, 2001. The front seat belts were removed from the vehicle and forwarded to ODI for analysis. No evidence of restraint failure was identified during the course of this investigation.</p>			
<p>18. <i>Key Words</i> Manual 3-point Restraint System Retractor-pretensioner Proper restraint Minor injury</p>		<p>19. <i>Distribution Statement</i> General Public</p>	
<p>20. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>21. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>22. <i>No. of Pages</i> 9</p>	<p>23. <i>Price</i></p>

**TABLE OF CONTENTS**

BACKGROUND ..... 1

SUMMARY

    Crash Site ..... 1

    Pre-Crash ..... 1

    Crash ..... 2

    Post-crash ..... 3

2001 TOYOTA RAV4

    Exterior Damage ..... 3

    Interior Damage ..... 4

    Manual Restraint System ..... 5

    Supplemental Restraint System ..... 6

OCCUPANT DEMOGRAPHICS ..... 7

DRIVER INJURY ..... 8

DRIVER KINEMATICS ..... 8

RIGHT FRONT PASSENGER INJURY ..... 8

RIGHT FRONT PASSENGER KINEMATICS ..... 9

CONCLUSION ..... 9

**ALLEGED SEAT BELT FAILURE INVESTIGATION  
VERIDIAN CASE NO: CA01-031**

**VEHICLE: 2001 TOYOTA RAV4  
LOCATION: FLORIDA  
CRASH DATE: MAY 2001**

***BACKGROUND***

This investigation focused on an alleged failure of the front right manual restraint in a 2001 Toyota Rav4 sport utility vehicle. The front manual restraint system consisted of a 3-point lap and shoulder belts with retractor-pretensioners for the driver and front right passenger. The vehicle was also equipped with a front Supplemental Restraint System that consisted of driver and front right passenger air bags. The retractor-pretensioners and frontal air bags deployed as a result of an L-configuration crash with a 1991 Ford Thunderbird. The front right restraint allegedly failed to properly restrain the 30 year old female passenger during the crash sequence. The front right passenger sustained a right 4<sup>th</sup> rib fracture, right toe fracture, forehead contusion, right thumb sprain, abdominal contusion and cervical strain as a result of the crash. The driver sustained an abrasion to his left forearm. The driver and front passenger of the Ford were reportedly not injured.

The Toyota's female passenger contacted the National Highway Traffic Safety Administration's (NHTSA) Office of Defects Investigations (ODI) regarding the incident. The ODI requested the Crash Investigations Division assign an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering. The vehicle was located at an automotive dealership and was inspected on May 29, 2001. The front seat belts were removed from the vehicle and forwarded to ODI for analysis. No evidence of restraint failure was identified during the course of this investigation.

***SUMMARY***

***Crash Site***

This two-vehicle crash occurred during the afternoon hours of May, 2001. At the time of the crash, it was daylight and the weather was not a factor. The road surface was dry. The crash occurred in the westbound lane of an east/west two-lane state route. There was a shallow right curve for westbound traffic. A gas station was located on the south side of the roadway. Directly opposite the gas station, a post office was located on the north side of the road. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is the police schematic of the crash.

***Pre-Crash***

The 2001 Toyota Rav4 was westbound, driven by a 35 year old restrained male, at an estimated 72 to 80 km/h (45 to 50 mph). A restrained 30 year old female was the front right passenger. The Toyota's

occupants were returning from a vacation to their out-of-state residence at the time of the crash. The rear seats of the vehicle had been removed and this cargo area was loaded with an estimated 100 kg (220 lb) of luggage. As the Toyota approached the area of the crash, a 1991 Ford Thunderbird exited the parking lot of the gas station in a northbound direction. It was the intention of the 66 year old female driver to cross the road and enter the parking lot of the post office. The driver of the Ford failed to recognize the presence of the Toyota and entered the road directly in the Toyota's path. The driver of the Toyota attempted to avoid the crash by steering to the right.

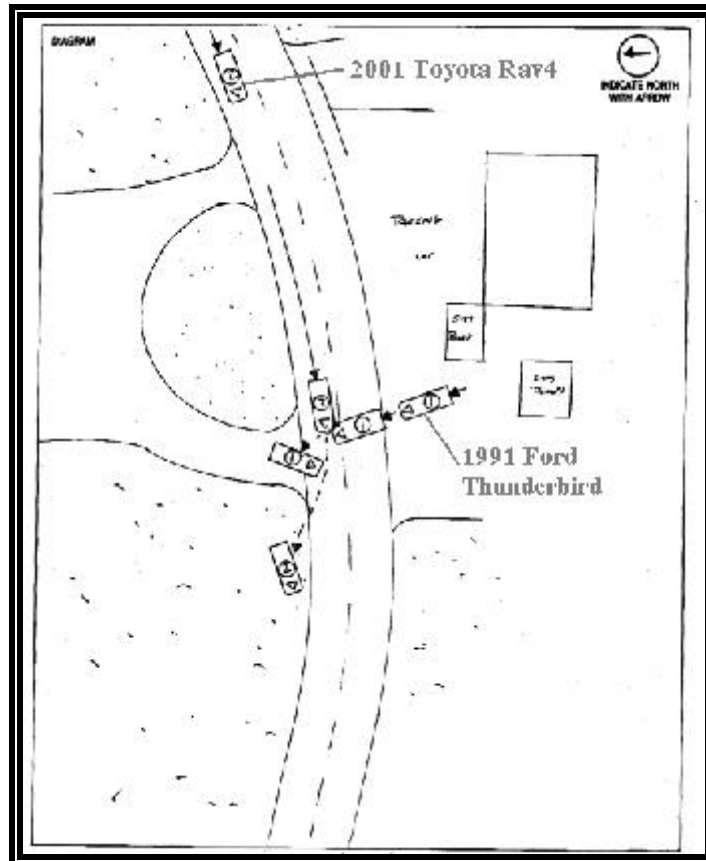


Figure 1: Police crash schematic.

### ***Crash***

The crash occurred with the left frontal area of the Toyota impacting the front aspect of the Ford's right side in a 12/03 o'clock impact configuration. The Toyota's delta V calculated by the Barrier Algorithm of the WINSMASH model was 17.7 km/h (11.0 mph). The force of the impact was above the threshold to fire the Toyota's retractor-pretensioners and frontal air bags. The impact of the Toyota forward of the Ford's center of gravity caused the Ford to begin to rotate counterclockwise. The dynamics of the initial collision caused the vehicles to impact a second time in a minor side slap. The left rear corner of the Toyota contacted the right side of the Ford. The vehicles then traveled to final rest. The Toyota came to

rest on the north road shoulder facing westward approximately 20 m (65 ft) from the point of impact. The Ford came to rest in the mouth of the post office entrance, facing southwestward, approximately 8 m (25 ft) from the point of impact.

### ***Post-crash***

The police and ambulance were dispatched to the crash site. The driver of the Toyota had exited the vehicle and was assisting the right passenger. The passenger sustained an abdominal contusion and right 4<sup>th</sup> rib fracture as a result of the seat belt loading. She also complained of a sprained finger, forehead contusion, right toe fracture and cervical strain. The passenger was transported, treated, and released from a local hospital the day of the crash. The driver of the Toyota reportedly sustained an abrasion of the left forearm and did not require transport. The driver and passenger of the Ford Thunderbird were not injured in the event.

### ***2001 TOYOTA RAV4***

The 2001 Toyota Rav4 was identified by the Vehicle Identification Number(VIN): JTEGH20V610 (production sequence deleted). The 4-door sport utility vehicle was manufactured in January 2001. The vehicle's power train consisted of a 2.0 liter, I-4 engine linked to a 4-speed automatic transmission. The brake system of the front-wheel drive vehicle was a front disc/rear drum ABS design. The electronic odometer could not be read. At the time of the inspection, the vehicle had been partially disassembled for insurance estimate purposes. The repair estimate totaled approximately \$14,000. The damage estimate was close to considering the vehicle a total loss.

### ***Exterior Damage***

**Figures 2 and 3** are the front and left front views of the Toyota Rav4, respectively. The front exterior damage was localized primarily on the front left corner of the vehicle. The direct contact damage measured 41 cm (16 in). The direct contact began 36 cm (14 in) left of center and extended to the left bumper corner. The crush profile measured at the bumper reinforcement bar was as follows: C1=14.0 cm (5.5 in), C2=14.0 cm (5.5 in), C3=7.0 cm (2.8 in), C4=2.5 cm (1.0 in), C5=0, C6=0. The Principle Direction of Force was within the 12 o'clock sector and was estimated to be 350 degrees (-10 degrees). There was no measurable change in the wheelbase dimensions. However, the left front suspension was damaged in the crash event and was displaced laterally. All the doors remained closed during the crash and were operational. The left side of the windshield was fractured in the impact. There was no side glazing damage. The total delta V calculated by the Barrier Model of the WINSMASH was 17.7 km/h (11.0 mph). The longitudinal and lateral delta V components were -17.5 km/h (-10.9 mph) and 3.1 km/h (1.9 mph), respectively. The Collision Deformation Classification (CDC) was 12-FLEW-1.



Figure 2: Front view of the Toyota Rav4.



Figure 3: Left front view of the Toyota.

Minor exterior damage consistent with a secondary side slap was identified on the left rear corner of the vehicle, **Figure 4**. The width of the direct contact measured 66 cm (26 in). The damage began 5 cm (2 in) aft of the left rear axle and extended to the left rear corner. The residual crush profile was as follows: C1=3.8 cm (1.5 in), C2=3.8 cm (1.5 in), C3=1.3 cm (0.5 in), C4=0. The CDC of this impact was 09-LBEW-1



Figure 4: Left rear side slap damage.

### *Interior Damage*

The vehicle's interior damage was limited to the deployment of the Supplemental Restraint System and minor occupant interior contacts. There was no interior damage related to the exterior forces of the crash.

No occupant contacts were identified within the front left (driver's) occupant space. There was no steering wheel deformation and no shear capsule displacement. The vehicle was operational and had been driven prior to SCI inspection. The driver's seat had been moved, therefore its at-crash position was unknown.

Two minor scuffs were identified on the right aspect of the mid-panel above the glove box. A horizontal oriented scuff measured 3.0 cm (1.2 in) in length and was located 37.6 cm (14.8 in) right of the vehicle's



center. A 3.0 cm (1.2 in) vertically oriented scuff was located 52.8 cm (20.8 in) right of center. These minor contact points did not result in any identified injury. The front right seat was in the full rear position. This was the at-crash seat track position as reported by the front right passenger.

### ***Manual Restraint System***

The subject vehicle was equipped with 3-point lap and shoulder belts for the five seat positions. The front restraints were equipped with retractor pretensioners and belt force limiters. **Figures 5 and 6** are views of the front belt systems in the buckled condition. Positive latching occurred between the latch plate and buckle of both restraints. There was no sign of a defective condition. The retractors of both restraints were locked in the at-crash position. The webbing would not spool in either direction indicating the pretensioners had fired and operated as designed. Obvious D-ring transfers to the webbings of each restraint were identified. The D-ring transfers on the left front and right front restraint measured 8.4 cm (3.3 in) and 6.4 cm (2.5 in), respectively. These webbing transfers were located below the D-ring, on the retractor side of the system, prior to removal of the restraints from the vehicle. This location of the transfers indicated there was not excessive pay-out of the webbing during the occupant's ride down. **Figures 7 and 8** are views of the front restraints after removal from the vehicle. The D-ring transfers are denoted by the yellow calibrated tape. The restraints were sent to ODI for further analysis.

All the evidence identified during the course of the SCI inspection indicated the driver and front right passenger were properly restrained at the time of the crash and the restraint system operated as designed. It should be noted that no complaint of restraint failure was ever registered with the police officer during the on-scene investigation.



**Figure 5:** Buckled left front restraint.



**Figure 6:** Buckled right front restraint.



Figure 7: Left front restraint.



Figure 8: Right front restraint.

### ***Supplemental Restraint System***

The 2001 Toyota Rav4 was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned driver and front right passenger air bags. The frontal air bags had deployed as a result of the above-threshold crash, **Figure 9**. The driver air bag module was configured in the typical manner in the center hub of the steering wheel. The asymmetrical module cover flaps opened as designed and were free of occupant contact. The driver air bag measured 66 cm (26 in) in its deflated state. The bag was tethered and was vented by two 3.8 cm (1.5 in) diameter ports located in the 11/1 o'clock sectors on the back side of the bag. The bag was identified by a manufacturer's label bearing the number: 011182H0668. A contact scuff measuring 3.8 cm x 10.2 cm (1.5 in x 4.0 in), width by height, was located in the 2 to 3 o'clock sector on the face of the bag. The scuff resulted from probable contact with the driver's upper extremities during the deployment sequence.



Figure 9: Interior view of the deployed air bags.

The front right passenger air bag module was a top mount design configured in the right aspect of the instrument panel. The symmetrical H-configuration module cover flaps were constructed of vinyl and measured 21.6 cm x 6.4 cm (8.5 in x 2.5 in), width by height. The air bag had deployed as design from

the module as a result of the above-threshold impact. The face of the bag measured 46 cm x 46 cm (18 in x 18 in) and extended 58 cm (23 in) from the module in its deflated state. It was not tethered and was vented by two 6.4 cm (2.5 in) diameter ports on the side panels of the air bag. There was no contact evidence on the face of the air bag. A 2.5 cm (1.0 in) vinyl transfer was identified on the center aspect of the inboard side panel. The transfer was located 15 cm (6 in) forward of the face of the bag and 8 cm (3 in) below the bag's top surface. During the crash sequence, the right passenger deflected the normal deployment path of the front right air bag into contact with the center mirror. The contact fractured the mirror and resulted in the vinyl transfer, **Figure 10**.



**Figure 10:** Contact between the center mirror and passenger air bag.

***OCCUPANT DEMOGRAPHICS***

	<i>Driver</i>	<i>Front Right Passenger</i>
Age/Sex:	35 year old/Male	30 year old/Female
Height:	180 cm (71 in)	160 cm (63 in)
Weight:	82 kg (180 lb)	63 kg (138 lb)
Restraint Usage:	3-pt. lap & shoulder	3-pt. lap & shoulder
Usage Source:	SCI inspection/PAR	SCI inspection/PAR
Medical treatment:	None	Treated and released

### ***DRIVER INJURY***

<b>Injury</b>	<b>Severity (AIS Update 98)</b>	<b>Injury Mechanism</b>
Left forearm abrasion	Minor (790202.1,2)	Expanding driver air bag

*Note: The above injury was identified during an interview with the front right passenger. Medical records were not available.*

### ***DRIVER KINEMATICS***

Immediately prior to the crash, the restrained driver was seated in a presumed normal posture with his seat adjusted to a rear track position. Reportedly, the driver steered right in an effort to avoid the crash. Upon impact, the retractor-pretensioner in the belt system fired, removing slack from the restraint, and the frontal air bags deployed. The deploying driver air bag contacted and abraded the driver's left forearm evidenced by the reported injury. The driver responded to the 12 o'clock direction of the crash force by initiating a forward trajectory and loading the manual belt system. This kinematic pattern was evidenced by a 8.4 cm (3.3 in) transfer to the webbing from the friction surface of the D-ring. The driver rode down the crash and rebounded back into his seat. The proper use of the 3-point restraint effectively restrained the driver and prevented occupant/interior contact, minimizing his injuries.

### ***FRONT RIGHT PASSENGER INJURY***

<b>Injury</b>	<b>Severity (AIS Update 98)</b>	<b>Injury Mechanism</b>
Right 4 <sup>th</sup> rib fracture	Minor (450212.1,1)	Inertial loading of the seat belt
Right toe fracture, NFS	Minor (853602.1,1)	Inertial loading of the toe pan
Abdominal contusion	Minor (590402.1,4)	Inertial loading of the seat belt
Left thumb sprain, NFS	Minor (750402.1,2)	Rebound contact to forehead (probable)
Forehead contusion	Minor (290402.1,7)	Rebound contact from left hand (probable)
Cervical strain (soreness)	Not coded per AIS rules	Inertial force of the head

*Note: The above injuries were identified during an interview with the front right passenger. Medical records were not available.*

### ***FRONT RIGHT PASSENGER KINEMATICS***

The restrained front right passenger was seated in a reported upright posture with her seat adjusted to a rear track position. Upon impact, the retractor-pretensioner fired and the frontal air bag system deployed in response to the above-threshold crash. The activation of the pretensioner removed the slack from her seat belt system. It was probable the passenger was startled by the impending crash and out-stretched her left arm to brace herself. The deploying passenger air bag contacted her left hand and forearm redirecting the extremity rearward into rebound. It was probable her left hand contacted her forehead resulting in the reported forehead contusion and sprained left thumb. The inboard side panel of the passenger air bag contacted and fractured the center mirror. A vinyl scuff mark on the side panel also evidenced this contact.

The passenger responded to the 12 o'clock direction of the impact force by initiating a forward trajectory and loading the belt system. The forward kinematic pattern was evidenced by a 6.4 cm (2.5 in) webbing transfer from frictional contact with the D-ring. The passenger sustained a right 4<sup>th</sup> rib fracture and abdominal contusion as a result of the seat belt loading. As the passenger's upper torso rode down the crash force, the head flexed forward and down in an arcing pattern. The anatomical structures of the neck reacted to and restrained the head resulting in the reported cervical strain. During this sequence, the passenger loaded the toe pan through her lower extremities resulting in the right toe fracture. The passenger then rebounded back into her seat. The proper use of the manual 3-point belt system effectively restrained the passenger during the crash sequence and helped to minimize her potential injury.

### ***CONCLUSION:***

The manual 3-point restraint systems for the driver and front right passenger operated as designed during the crash and were found not to be defective.