

Advanced Occupant Protection System Investigation/ Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS03033
2004 Toyota Corolla S Four-Door Sedan
California
September, 2003

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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 The focus of this investigation was the performance of the Advanced Occupant Protection System installed in a 2004 Toyota Corolla. The 2004 Toyota Corolla S four-door sedan that was being driven southbound by a restrained 50 year-old male at a driver estimated speed of 89 km/h (55 mph). A non-contact vehicle that was traveling directly in front of the case vehicle, suddenly changed lanes to the middle travel lane in order to avoid a disabled 1992 Dodge Ram van (other vehicle) that was stopped in the first lane from the right with its hazard lights activated. The driver of the case vehicle detected the stopped van and applied his brakes, but was unable to avoid the impending impact. The front bumper of the case vehicle underrode the rear bumper of the Dodge van in an in-line collision. There were no air bag deployments.					
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Dynamic Science, Inc.
Crash Investigation
Case Number: DS03033

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BACKGROUND:

Description

The focus of this investigation was the performance of the Advanced Occupant Protection System installed in a 2004 Toyota Corolla. The 2004 Toyota Corolla S four-door sedan that was being driven southbound by a restrained 50 year-old male at a driver estimated speed of 89 km/h (55 mph). A non-contact vehicle that was traveling directly in front of the case vehicle, suddenly changed lanes to the middle travel lane in order to avoid a disabled 1992 Dodge Ram van (other vehicle) that was stopped in the first lane from the right with its hazard lights activated. The driver of the case vehicle detected the stopped van and applied his brakes, but was unable to avoid the impending impact. The front bumper of the case vehicle underrode the rear bumper of the Dodge van in an in-line collision. There were no air bag deployments.

This case was initially identified by a NHTSA review of GES police reports. A copy of the police report was forwarded to DSI on October 9, 2003 with instructions to locate the case vehicle and gain permission to harvest the EDR, air bag sensor and conduct an on-site investigation. Field work was completed on November 8, 2003. The EDR was harvested and submitted to NHTSA. It was then forwarded to Toyota for interpretation. The EDR was apparently lost and no EDR data was available at the time of this report.

SUMMARY

Crash Site

This two vehicle front to rear impact crash occurred in September, 2003 at 0440 hours. It was dark at the time and the overhead street lights illuminated the roadway. The weather was



Figure 1. Front, right view of case vehicle showing significant underide deformation



Figure 2. View showing the approximate impact area



Figure 3. Overhead look-back view (north) showing area of the collision

clear and the level asphalt roadway surface was dry and travel worn. The crash occurred on the southbound travel lanes of an interstate freeway. The roadway consists of three southbound travel lanes and five northbound travel lanes. The east roadside of the southbound travel lanes is bordered by a concrete shoulder with an adjacent raised concrete median. A center concrete wall barrier separates the southbound and northbound travel lanes. The west roadside of the southbound travel lanes consists of a concrete drainage edge with an adjacent asphalt shoulder. There were no traffic controls present and the speed limit is 89 km/h (55 mph).

Pre-Crash

The case vehicle is a 2004 Toyota Corolla S four-door sedan that was being driven by a restrained 50 year-old male (168 cm, 66 in/ 86 kg, 190 lbs). There is a continuous loop, 3-point lap and shoulder belt present at the drivers seated position and the free sliding latch plate was scratched with striations which indicated regular or historical usage. The lap and shoulder restraints at the front seated positions are equipped with pretensioners which did not activate. The case vehicle was traveling southbound on the interstate roadway in the first lane from the right at a driver estimated speed of 89 km/h (55 mph).

Crash

A non-contact vehicle that was traveling directly in front of the case vehicle, suddenly changed lanes to the middle travel lane in order to avoid a disabled 1992 Dodge Ram van (other vehicle) that was stopped in the first lane from the right with its hazard lights activated. The driver of the van (other vehicle) had exited the vehicle and was standing on the west asphalt shoulder edge. The driver of the case vehicle detected the stopped van and applied his brakes, but was unable to avoid the impending impact. The front bumper of the case vehicle (12FDEW1) under rode the rear bumper of the Dodge van in an in-line collision.



Figure 4. View of case vehicle with hood and fascia removed exposing the extent of upper bumper deformation

Post-Crash

The case vehicle came to rest in the original lane of travel. The driver of the case vehicle was reportedly uninjured as a result of the crash and was able to exit the vehicle unassisted.

The case vehicle underwent a calculated longitudinal change in velocity of -28.0 km/h (-17.4 mph) utilizing the Missing Vehicle algorithm of the WinSmash program. The results appear high. The frontal air bags did not deploy. After the crash, the case vehicle was subsequently towed from the crash scene.

VEHICLE DATA - 2004 Toyota Corolla S Four Door Sedan

The 2004 Toyota Corolla S four door sedan was identified by the Vehicle Identification Number (VIN): 1NXBR32E24ZXXXXXX

The 2004 Toyota Corolla S Four-Door Sedan was equipped with a 1.8 liter in-line 4 cylinder /130 hp engine along with a 5-speed automatic transmission. The case vehicle is equipped with power-assisted ventilated front disc and rear drum brakes. The vehicle's drive system consists of front wheel drive and the steering components are composed of an engine speed-sensing, power-assisted rack-and-pinion system.

The reading from the instrument panel odometer was not readable due to LED and power outage.

The 2004 Toyota Corolla S four door sedan was equipped with Bridgestone Insignia S/E 200 P195/65R15 S89 tires. The specific tire data is as follows:

Tire	Tread	Measured pressure	Manufacturer recommended maximum cold pressure
LF	8 mm (10/32 in)	255 kPa (37 psi)	303 kPa (44 psi)
LR	8 mm (10/32 in)	234 kPa (34 psi)	303 kPa (44 psi)
RR	8 mm (10/32 in)	255 kPa (37 psi)	303 kPa (44 psi)
RF	8 mm (10/32 in)	255 kPa (37 psi)	303 kPa (44 psi)

The front seating positions in the 2004 Toyota Corolla S four door sedan were configured with fabric covered forward facing bucket seats. Both front bucket seats are equipped with adjustable head restraints that were undamaged. The front left seat was adjusted between the center and the rear-most position. The second seating row consists of a fabric covered 60/40 split bench seat with folding seatbacks. There are adjustable head restraints available at the outboard rear seated positions and they were undamaged.

VEHICLE DAMAGE

Exterior Damage - 2004 Toyota Corolla S

Damage Description: Moderate/Primary Frontal Impact: The frontal plane of the case vehicle underrode the other vehicle which resulted in a “step” in the deformation pattern. The front bumper revealed no crush while the grille and upper radiator support was displaced significantly rearward. Crush averaging was utilized and the maximum crush was calculated to be 19.0 cm (7.5 in.) located at C4. Damaged components included the front fascia cover, hood, grille, upper/lower radiator supports, both fenders and the laminated windshield glazing was cracked.

CDC: 12FDEW1

Delta V:	Total	26.0 km/h ¹ (16.2 mph)
	Longitudinal	-26.0 km/h (-16.2 mph)
	Latitudinal	0.0
	Energy	30,019 joules

C-measurements (crush profile): Crush averaging was utilized due to the underride “step” in deformation. Six equidistant crush measurements were documented at the bumper bar level and the crush profile is as follows: C₁ = 0 cm, C₂ = 0 cm, C₃ = 0 cm, C₄ = 0 cm, C₅ = 0 cm, C₆ = 0 cm. The front bumper bar revealed no residual crush. A second set of crush values was documented at the upper radiator support level and the crush pattern was 22.0 cm (8.7 in) at C₁, 27.0 cm (10.6 in) at C₂, 36.0 cm (14.2 in) at C₃, 38.0 cm (15.0 in) at C₄, 30.5 cm (12.0 in) at C₅ and 24.5 cm (9.6 in) at C₆. Crush averaging yielded the following crush profile: C₁=11.0 cm (4.3 in), C₂ = 13.5 cm (5.3 in), C₃ = 18.0 cm (7.0 in), C₄ = 19.0 cm (7.5 in), C₅ = 15.3 cm (6.0 in), C₆ = 12.3 cm (4.8 in).

Interior Damage - 2004 Toyota Corolla S

The interior greenhouse area of the case vehicle was void of any intruding components and the case vehicle’s integrity was not compromised. The rear edge of the hood was displaced rearward which ultimately cracked the AS-1 windshield glazing. A slight scuff mark was identified to the lower instrument panel and may have been the result of contact from the driver’s lower right leg.

¹ Calculated utilizing the Missing Vehicle Algorithm of the WinSmash 2.41 program

The interior of the case vehicle consisted of two front seated positions with fabric covered bucket seats. The second row was comprised of a fabric covered split bench seat with folding seatbacks. There are adjustable head restraints at the outboard rear seated positions. There was no damage to the interior seats or head restraints.

MANUAL RESTRAINT SYSTEMS - 2004 Toyota Corolla S

The driver's manual restraint system consisted of a continuous loop three-point lap and shoulder belt with a free sliding latch plate and an Emergency Locking Retractor (ELR). The shoulder belt adjuster was in the full up position. The driver's lap and shoulder belt exhibited evidence of historical usage. The shoulder belt webbing did not exhibit evidence of stretching due to occupant loading.

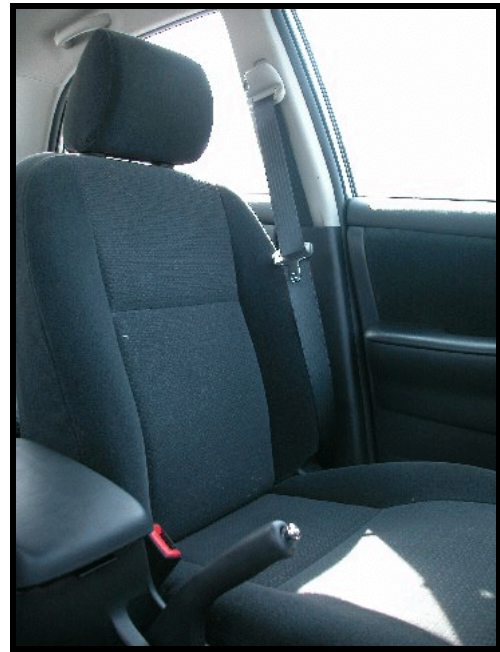


Figure 5. View showing manual restraint system at the front right driver's position

The front, right seat (not occupied) was also equipped with a continuous loop three-point lap and shoulder belt with a free sliding latch plate. The restraint is equipped with a shoulder belt adjuster.

Both front seats are equipped with pretensioners (Automatic Tensioning System) and did not activate due to the frontal impact.

The three seated positions of the rear bench seat are equipped with manual three-point lap and shoulder belts with free sliding latch plates and switchable (ELR/ALR) retractors.

FRONTAL AIR BAG SYSTEM - 2004 Toyota Corolla S

This vehicle was equipped with an advanced occupant protection system that consists of dual-stage/dual-threshold driver and front right passenger air bags. The air bag sensor assembly consists of a safing sensor and an air bag sensor. There were no air bag deployments in this override type crash. According to the Corolla Owner's Manual: *"The front air bags will deploy if the severity of the impact is above the designed threshold level, comparable to an approximate 25 km/h (15 mph) collision when impacting straight into a fixed barrier that does not move or deform. This threshold velocity will be considerably higher if the vehicle strikes an object, such as a parked vehicle or sign post, which can move or deform on impact, or it is involved in an underride collision (e.g. a collision in which the nose of the vehicle "underrides", or goes under, the bed of a truck, etc.)."*

Both front seat positions are also equipped with three-point safety seat belts with pretensioners. The front seat belt pretensioners are controlled by the air bag sensor assembly. Once the front seat belt pretensioners have activated, the seat belt retractors remain locked. As indicated earlier, neither of the front pretensioners actuated and were not locked.

The air bag sensor assembly (Toyota part number 89170-02190) was removed from the case vehicle and sent to NHTSA on October 30, 2003 for reading of the recorded crash data by Toyota Motor Company. The sensor assembly was apparently lost at some point and no sensor data is available for this report.



Figure 6. View showing non-deployed steering wheel hub mounted air bag



Figure 7. Air bag sensor module (EDR)

VEHICLE DATA - 1992 Dodge Ram van

Description:	1992 Dodge Ram van	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	Unknown	
Cargo:	Unknown	
Damage Description:	Rear deformation which ultimately required towing from the scene	
TDC:	N/A	
Delta V:	Total	17.0 km/h (10.6 mph)
	Longitudinal	17.0 (10.6 mph)
	Latitudinal	0.0 km/h
	Energy	20,687 joules

OCCUPANT DEMOGRAPHICS - 2004 Toyota Corolla S Four-Door Sedan

	Driver
Age/Sex:	50/Male
Seated Position:	Front, left
Seat Type:	Bucket, fabric covered
Height:	168 cm (66 in.)
Weight:	86 kg (190 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	Unknown
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Upright, specifics are unknown
Hand Position:	Unknown
Foot Position:	Right foot depressing the brake pedal and left foot on the floor
Restraint Usage:	Three-point manual lap and shoulder restraint used, presumably in a correct fashion with the shoulder belt webbing extending across his front (chest) and the lap belt extending across his hips
Air bag:	Non-deployed

OCCUPANT INJURIES - 2004 Toyota Corolla S

Driver: No reported injuries.

OCCUPANT KINEMATICS - 2004 Toyota Corolla S**Driver kinematics**

The 50 year-old male driver (168 cm, 66 in/86 kg., 190 lbs.) was wearing the available three-point lap and shoulder restraint and had the upper shoulder belt anchorage adjusted to the full up position. The seat was adjusted between the middle and rearmost seat track position and the seatback support was reclined rearward 21 degrees from a vertical upright position. It is unknown whether the driver had one or two hands on the steering wheel rim and his right foot was depressing the brake pedal while his left foot was on the floor/toe pan.

He responded to the 12 o'clock impact force by moving directly forward. Although the lap and shoulder belt webbing showed no stretching, D-ring material transfers or retractor scuff marks, he likely loaded the applied restraint which prohibited extended forward movement. As his lower torso was restricted by the lap belt webbing, it is likely that his right lower leg contacted the lower instrument panel/knee bolster as evidenced by a documented residual scuff mark. This contact, however, did not result in a reported injury.

The driver rebounded into his respective seatback support as the case vehicle came to rest. The police report indicated that the driver did not sustain any injuries as a result of the crash and did not require any medical treatment at the scene.

Attachment 1. Scene Diagram

