

Unintended Acceleration/Hybrid ODI Vehicle Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS07010
2005 Toyota Prius
Washington
March 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.

1. Report No. DS07010	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Unintended Acceleration/Hybrid ODI Vehicle Investigation			5. Report Date September 24, 2007	
			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. 299 West Cerritos Avenue Anaheim, CA 92805			10. Work Unit No. (TRAIS)	
			11. Contract or Grant no. DTNH22-01-C-27002	
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NRD-111) National Highway Traffic Safety Administration 1200 New Jersey Ave, SE Washington, DC 20590			13. Type of report and period Covered [Report Month, Year]	
			14. Sponsoring Agency Code	
15. Supplemental Notes				
16. Abstract <p>This on-site investigation focused on the unintended acceleration of a 2005 Toyota Prius, as well as this hybrid vehicle's conformance to Federal Motor Vehicle Safety Standard, Section 571.305, Standard No.305 (Electric-powered vehicles: electrolyte spillage and electrical shock protection). The crash occurred on private property just beyond an interstate off ramp. The case vehicle was a 2005 Toyota Prius driven by 66-year-old male. The driver indicated that he had recently purchased the vehicle. According to the driver, two dealers had inspected the vehicle with no issues reported and one had certified it. As he was returning from the dealership, the driver indicated that the vehicle began accelerating. The driver stated that he applied both the service brakes and the parking brake, but the vehicle would not stop. The vehicle left the initial roadway, traveled down an off ramp and eventually entered the parking lot of a convenience mart store. The vehicle continued on and struck the convenience mart with its front end. The vehicle penetrated the store. The driver of the case vehicle was able to exit the vehicle under his own power. He did not sustain any injuries. The vehicle then caught on fire. The fire department arrived shortly after the crash. They put out the fire but were concerned by the high voltage system and the possibility of electrocution. After the fire was put out, fire inspectors contacted a local automobile dealership who then sent a service technician to the site to deactivate the power leads for the rear traction battery by pulling the service plug.</p>				
17. Key Words Unintended acceleration, hybrid, battery, fire, floor mat			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
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BACKGROUND

This on-site investigation focused on the reported unintended acceleration of a 2005 Toyota Prius four-door sedan, as well as this hybrid vehicle's conformance to Federal Motor Vehicle Safety Standard, Section 571.305, Standard No.305 (Electric-powered vehicles: electrolyte spillage and electrical shock protection).

This single vehicle crash occurred in March 2007 at 1245 hours. The crash occurred on private property just beyond an interstate off ramp. The case vehicle was a 2005 Toyota Prius driven by 66-year-old male. The driver indicated that he had recently purchased the vehicle. As he was returning from the dealership, the driver indicated that the vehicle began accelerating. The driver stated that he applied both the service brakes and the parking brake, but the vehicle would not stop. The vehicle left the initial roadway, traveled down an off ramp and eventually entered the parking lot of a convenience mart store. The vehicle continued on and struck the convenience mart with its front end. The vehicle penetrated the store. A clerk was temporarily pinned behind a counter. The vehicle then caught on fire. The fire department arrived shortly after the crash. They put out the fire but were concerned by the high voltage system and the possibility of electrocution. After the fire was put out, fire inspectors contacted a local automobile dealership who then sent a service technician to the site to deactivate the power leads for the rear traction battery¹ by pulling the battery service plug. The driver of the case vehicle was able to exit the vehicle under his own power. He did not sustain any injuries.



Figure 1. Front right, 2005 Toyota Prius



Figure 2. Exemplar vehicle, 2005 Toyota Prius

This hybrid vehicle ODI case was identified by NHTSA from an on-line news video. DSI was assigned the case on March 8, 2007. DSI located the vehicle on March 11, 2007 and obtained permission to inspect the vehicle on March 12, 2007. Field work was conducted during the week of March 19, 2007. A second vehicle inspection took place later in the month to remove and inspect the vehicle brakes. The driver also filed a Vehicle Owners' Questionnaire (VOQ) report under ODI 10209497 in November, 2007.

¹There are actually two batteries on hybrid vehicles, the traction battery and the auxiliary 12-volt battery, which powers accessories and the car's computer, similar to a conventional vehicle. The traction battery in Prius uses Nickel-Metal-Hydrate (NiMH) chemistry. Source: www.toyota.com/disclaimers/hybrid_battery.html

SUMMARY

Crash Site

This single vehicle crash occurred off-road at a gas station/convenience store. The case vehicle was initially traveling north on an interstate highway. According to the driver, he was unable to slow the vehicle and exited onto an off ramp. The off-ramp departs the interstate in a right hand curve and then straightens out to a 90 degree angle from the interstate so that vehicles are traveling east. The off ramp is configured with two lanes that are separated by a solid white line. There is a negative 2% grade at this location. This roadway is controlled by tri-color traffic signals. The roadway intersects a north/south roadway. The north/south roadway is configured with two lanes in each direction that were separated by a reversible center lane. There is a positive 4% grade in the northbound direction. On the eastern side of this road there is a 10 m (32 ft) wide driveway leading into the convenience store. The southern most corner of the store is located 30 m (97 ft) east of the road edge.

At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface of the off ramp was dry.



Figure 3. Case vehicle traveling down off ramp (east)



Figure 4. Case vehicle entering cross street at end of ramp

Pre-Crash

The case vehicle was initially traveling north on an interstate highway. The driver indicated that he had recently purchased the vehicle. According to the driver, two dealers had inspected the vehicle with no issues reported and one had certified it. The last location the vehicle was fully stopped was approximately 16 km (10 miles) from the crash site. As the driver was returning from the dealership, the driver indicated that he took his foot off the accelerator and the vehicle continued without slowing. The driver stated that he began braking, but every time he took his foot off the brake the vehicle would accelerate back up to 121 km/h (75 mph). The driver indicated that he continued riding the brake to keep the vehicle under control. He stated that there was heavy traffic on the interstate and that it was necessary to dodge traffic at various points. He exited the interstate using an off-ramp on the right side. The light at the end of the off-ramp was green and the driver continued through the cross street and entered the parking lot of a convenience store.



Figure 5. Impact with convenience store (fencing not present at time of crash)



Figure 6. Toyota Prius inside convenience store (in-store camera)

Crash

The vehicle continued on and struck the convenience mart with its front end. The vehicle penetrated the store. A clerk was temporarily pinned behind a counter.

Post-Crash

The driver of the case vehicle was able to exit the vehicle under his own power. The driver's door remained closed and operational. The driver did not sustain any injuries. After exiting the vehicle, the driver saw a witness and the store clerk. He also saw the fire beginning at the front of the Prius. The witness suggested that they all leave the building.

The fire department arrived shortly after the crash. They put out the fire but were concerned by the high voltage system and the possibility of electrocution. After the fire was put out, fire inspectors contacted a local automobile dealership who then sent a service technician to the site to deactivate the power leads for the rear traction battery by pulling the service plug.

VEHICLE DATA - 2005 Toyota Prius

The 2005 Toyota Prius was identified by the Vehicle Identification Number (VIN): JTDKB20U957xxxxxx. The vehicle's odometer could not be read, as there was no power to the instrument panel. The driver estimated the mileage at 56,003 km (34,800 miles) on the VOQ report. The Toyota Prius was a 5-door hatchback that was equipped with a 1.5 liter, four-cylinder engine, an electric motor, a continuously variable transmission, a sealed nickel-metal hydride traction battery, rack and pinion steering with electric power assist, and power-assisted front disc/rear drum brakes with an anti-lock brake system and integrated regenerative braking, and a tilt steering wheel. The Prius was configured with a Goodyear Integrity P185/65R15 tire for the right rear; the remaining tires were flattened and burned.

The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Flat	Unknown	No	Flat/burned
LR	Flat	6 mm (8/32 in)	No	Flat/burned
RR	179 kPa (26 psi)	9 mm (11/32 in)	No	None
RF	Flat	6 mm (7/32 in)	No	Flat/burned

The seating in the Toyota Prius was configured with fabric covered front bucket seats with adjustable head restraints and a rear 60/40 split bench seat with folding backs and adjustable head restraints for all three second row seating positions.

Vehicle Damage

Exterior Damage -2005 Toyota Prius

The 2005 Toyota Prius sustained moderate front end damage from the impact with the convenience store and major damage from the post-crash fire. For the frontal impact, the direct damage began at the right front bumper corner and extended across the entire end width. There was also contact damage to the right side, left side and roof that occurred as the Prius penetrated the building.

Six crush measurements were documented at the bumper level as follows: C1 = 0 cm (0 in), C2 = 1.0 cm (0.4 in), C3 = 1.0 cm (0.4 in), C4 = 2.0 cm (0.8 in), C5 = 3.0 cm (1.2 in), C6 = 27.0 cm (10.6 in). The Collision Deformation Classification (CDC) for the impact with the building was 12FDEW2. The barrier option of the WinSmash Program calculated a barrier equivalent speed of 15.3 km/h (9.5 mph). This is a borderline reconstruction since the vehicle struck a yielding object.

The Prius sustained burn damage on all planes. It appears likely that the heat generated by the continual brake application may have been the source of the fire. All the glazing on the vehicle was gone. All the doors were closed. They could not be opened because all the handles/grips had been carbonized in the fire and were totally frangible and broke away when any pressure was applied. The doors were later pried open by this investigator.



Figure 7. Front right, Toyota Prius



Figure 8. Right side view, Toyota Prius

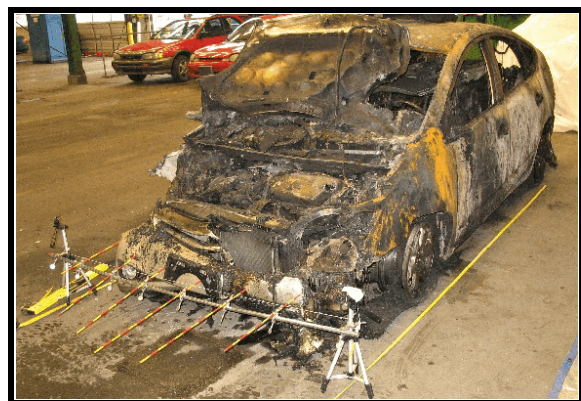


Figure 9. Front left, Toyota Prius



Figure 10. Overview of engine compartment



Figure 11. Exemplar view of engine compartment

Interior Damage -2005 Toyota Prius

The 2005 Toyota Prius sustained major interior damage due to the fire. The seats were burned down to their frames. The instrument panel and most plastic surfaces were melted.

Conformance to Sec. 571.305 Standard No.305; Electric-powered vehicles: electrolyte spillage and electrical shock protection

The case vehicle was examined to determine compliance with the 305 Standard.

- There were no indications of electrolyte spillage from the propulsion battery.
- There was no movement of the battery module.
- The electrical isolation test was not conducted. There was no power available and the wiring was generally burned.
- There was no way to determine if there indications of any arcing, fire or component meltdown.

The vehicle's service plug was pulled after the crash. The service plug shuts off the high voltage circuit of the high voltage battery when this plug is removed for vehicle inspection or maintenance. Overviews of the service plug and high voltage battery location are shown on the following page. The service plug is accessed through the deck behind the rear seats. It is necessary to remove the spare tire tool package to access the plug.



Figure 12. Exemplar view of battery access with cover in place



Figure 13. Exemplar view of battery access with cover removed

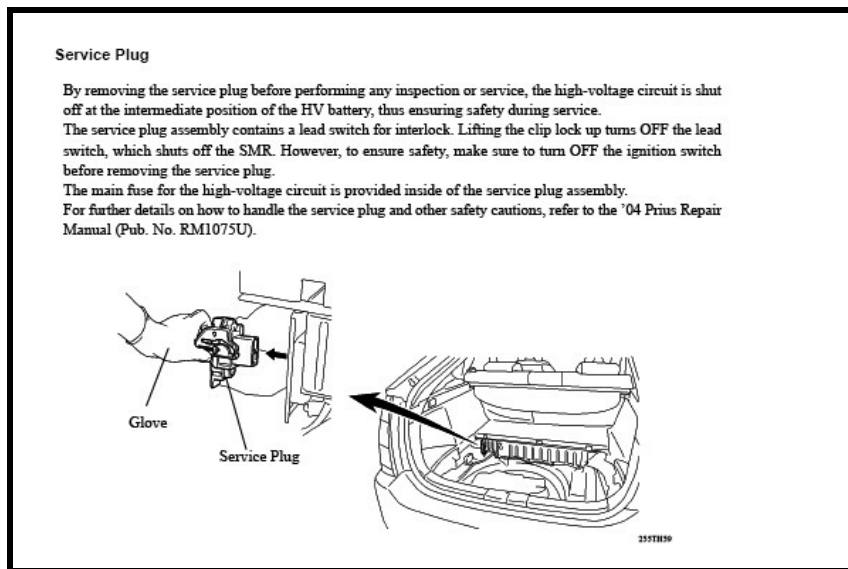


Figure 14. Service plug removal instructions



Figure 15. Service plug location on case vehicle

Floor Mat/Accelerator Discussion

The driver of the Prius stated that the vehicle began accelerating on its own. He also stated that he could not stop the vehicle using either the parking brake or the service brakes. A rubberized all weather mat had been installed on top of the floor carpeting. The floor carpeting was covered by plastic sheeting with a printed message that stated: Dealer must remove protective cover. The rubberized floor mat was designed to be secured to the floorboard by plastic retention devices near the front of the driver's seat. The retention devices were destroyed by the vehicle fire. The interaction between the rubber mat and the accelerator pedal was examined. As the pedal was pressed down the bottom edge of the pedal became trapped by the leading edge of the rubber mat. The pedal remained trapped by the mat until freed by the investigator.

Service Brakes Discussion

The front brakes were removed and examined by the DSI investigator. All the brake pads exhibited wear that was consistent with the brakes being applied for a long period of time while the vehicle was at speed. The brake pads were worn down to the metal. There were also indications of excessive temperature.



Figure 16. Plastic sheet on top of floor carpeting



Figure 17. Pedal/mat before pressing pedal



Figure 18. Pedal pressed down, trapped by mat



Figure 19. Close up. Pedal pressed down, trapped by mat



Figure 20. Right front rotor



Figure 21. Left front rotor



Figure 22. Front right inner pad



Figure 23. Left front outer pad



Figure 24. Front right outer pad



Figure 25. Left front inner pad

Fire Discussion

The case vehicle struck and penetrated the building. After the vehicle came to rest, the driver was able to exit under his own power. As he walked out of the building, he saw some small flames visible in the upper portion of the left front wheel well. By the time he got outside and looked back in, there was a large fire at the front of the vehicle. The fire consumed the vehicle and essentially gutted the building. After the fire was put out, fire inspectors contacted a local automobile dealership who then sent a service technician to the site to deactivate the power leads for the rear traction battery by pulling the service plug. It appears likely that the heat generated by the continual brake application may have been the source of the fire.

Manual Restraints -2005 Toyota Prius

The 2005 Toyota Prius was configured with manual 3-point lap and shoulder belts for each seating position. Both front seat safety belts were equipped with retractor pretensioners and adjustable D-rings that were in the full down positions. The status of the belts themselves could not be determined due to burn damage.

Supplemental Restraint Systems -2005 Toyota Prius

The 2005 Toyota Prius was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The Prius was also equipped with seat back mounted side air bags. According to the driver, there were no air bag deployments as a result of the impact with the building.



Figure 26. Driver's air bag



Figure 27. Driver's seat back mounted side air bag

OCCUPANT DEMOGRAPHICS - 2005 Toyota Prius

	Driver
Age/Sex:	66/Male
Seated Position:	Front left
Seat Type:	Bucket
Height:	183 cm (72 in)
Weight:	86 kg (190 lbs)
Occupation:	Retired
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	>20 years
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, 10/2 o'clock position
Foot Position:	Right foot on brake, left on floor board
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Did not deploy in crash, deployed later during fire

Driver Kinematics

The 66-year-old make driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat track was between the mid and full back track position and the seat back was slightly reclined. According to the driver, both of his hands were on the steering wheel and his right foot was on the brake. He was actively steering and braking prior to impact. At impact, the driver initiated a forward trajectory and likely loaded the safety belt to some extent. The driver reported that this was a soft impact. He did not report any injuries. He was able to exit the vehicle under his own power.

Injuries

Driver was not injured.

Attachment 1. Scene Diagram

