U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

NHTSA Toyota Pre-Crash EDR Field Inspections

During March – August 2010

February 2011

DISCLAIMER

Technical Report Documentation Page

1. Report No. NHTSA-NVS-2011-ETC-SR10	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle NHTSA Toyota Pre-Crash EDR Field Inspections During March – August 2010		5. Report Date February 2011 6. Performing Organization Code NVS
7. Author(s)		8. Performing Organization Report No. NHTSA-NVS-2011-ETC-SR10
9. Performing Organization Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration 1200 New Jersey Ave., S.E. Washington, DC 20590		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Ave., S.E. Washington, DC 20590		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes This report provides supplementary information to NHTSA Report No. NHTSA-NVS-2011-ETC, "Technical Assessment of Toyota Electronic Throttle Control (ETC) Systems," January 2011.		
16. Abstract		
17. Key Words Sudden acceleration, unintended acceleration, electronic throttle control, "Silver Book,"	18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages / 22. Price

Form DOT F 1700.7 (8-72)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 PURPOSE

As part of its overall efforts[1] to identify vehicle- based causes of unintended acceleration (UA) not already covered by existing safety recalls in Toyota vehicles, NHTSA conducted 58 onsite inspections of vehicles reportedly involved in UA incidents from March to August of 2010. Until March of this year, NHTSA's UA field inspections relied solely on documentation of the vehicle and scene physical conditions, as well as the vehicle service/warranty history and testimony from involved parties. This tried and true methodology has served reliably over the years, identifying or ruling out the involvement of vehicle- based safety defects in incidents of interest. Unfortunately, this methodology does not reliably collect evidence of driver actions immediately prior to the crash, leaving ambiguity concerning the possible contribution of driver error. This was illustrated in a well-known incident that took place in 2003 and caused 10 fatalities and 63 injuries, and was investigated in-depth by the National Transportation Safety Board (NTSB). At the end of the 13 month investigation, the NTSB issued a report[2] concluding that the subject driver made an error in response execution, inadvertently accelerating when he intended to brake. Subsequently the NTSB recommended that NHTSA require the installation of event data recorders (EDR) [3] in all newly manufactured light-duty vehicles once standards for event data recorders are frozen.

Absent physical evidence of a vehicle- based defect in some cases, ambiguity remained concerning the cause of many incidents reported to NHTSA as unintended acceleration. As a result, NHTSA sought the capability to collect EDR data from the subject vehicles. An emphasis was placed on the collection of pre-crash data so as to gain more insight into the vehicle's performance and to discern the driver's actions during the incident in the effort to identify a vehicle- based defect.

[1] For more information on this effort, see Report No. NHTSA-NVS-2011-ETC.
[2] NTSB report PB 2004-916204
Rear-End Collision and Subsequent Vehicle Intrusion Into Pedestrian Space at Certified Farmer's Market
Santa Monica, CA August 3, 2004
[3] Event Data Recorders (EDRs) are devices that historically have been used to record information related to a vehicle crash. More specifics can be found in Report No. NHTSA-NVS-2011-ETC-SR04.

2.0 BACKGROUND

2.1 EDR Readers

Until early 2010, NHTSA had no ability to retrieve data from EDRs contained within Toyota vehicles. In fact, Toyota has maintained that it possessed only one prototype EDR reader in North America until the early 2010. Throughout the first quarter of 2010, Toyota expanded its contingent of North American EDR readers, furnishing readers to NHTSA, Transport Canada, and deploying its own. While increasing the availability of its EDR readers, Toyota still referred to them as prototypes and did not make them available for commercial sale.

NHTSA received its first Toyota EDR reader in early March and immediately began conducting field inspections of alleged UA incidents. Throughout March and early April, NHTSA obtained an additional nine EDR readers and trained[4] staff from its Office of Defects Investigation (ODI), Special Crash Investigation (SCI) office, and Vehicle Research and Testing Center (VRTC) in their use. All ten kits were deployed by the second week of April with the following allocation (Table 1):

Table 1: NHTSA EDR Reader Allocation by Office

Office	EDR Readers	
ODI	5	50%
SCI	4	40%
VRTC	1	10%
Total	10	100%

2.2 EDR Validation

A commercially available EDR reader kit[5] exists that covers many Chrysler, Ford, and General Motors vehicles and whose outputs are generally accepted when accompanied by consistent crash reconstruction work. No such general acceptance exists for the prototype Toyota readers.

NHTSA validated Toyota EDR outputs in six major areas:

[4] A synopsis of EDR default data values and basic information on reading the outputs is enclosed in Report No. NHTSA-NVS-2011-ETC-SR05.
[5] Crash Data Retrieval (CDR) kit sold by Bosch

1. EDR outputs were compared to the physical facts of each field inspection that was conducted;
2. Track testing[6] with independent instrumentation validated the pre-crash data elements for: brake light switch status, accelerator pedal position, and vehicle speed;
3. EDR reader veracity and consistency were verified by reading one of the track test EDRs with each of the kits in NHTSA's possession;
4. Comparison of data retrieved and reviewed with different EDR reader software versions showed consistent results[7];

The validation work was extensive and is addressed in further detail in the appendices. Notwithstanding the "prototype" labeling or characterizations from external parties, NHTSA has high confidence in the veracity of data recovered from Toyota's EDRs and, similar to the Bosch CDR, this information is very valuable when considered in concert with the physical facts of a given incident.

2.3 Availability of Pre-Crash Capable EDRs in Toyota Vehicles

EDR availability in Toyota manufactured vehicles over the last decade has improved with pre-crash- capable models constituting a growing share of EDR- equipped models over time. Pre-crash data availability varies by model and model year with pre-crash- capable EDRs being deployed incrementally by platform (as opposed to all at once).

MY 2007 was notable in that it was the first year in which the number of Toyota vehicle models equipped with pre-crash- capable EDRs outnumbered those equipped with post-crash- only EDRs. This was also the model year in which the Camry and ES350 transitioned from post-crash only to pre-crash EDRs. All Toyota manufactured vehicles capable of storing pre-crash data come equipped with electronic throttle control. However not all Toyota products that contain EDRs necessarily have ETC.

[6] Report No. NHTSA-NVS-2011-ETC-SR07.
[7] Report No. NHTSA-NVS-2011-ETC-SR08.

2.4 Involved Parties

Field Inspections were conducted by three NHTSA offices including the Office of Defects Investigation, Special Crash Investigation, and the Vehicle Research and Test Center. Field staffing supplied by the three offices covered a significant cross-section of technical staff and included experienced crash investigators, defect investigators and screeners, and test engineers. All three offices assigned staff previously involved in field inspection work to train additional staff and lead the first field inspections. All of the results were collectively vetted and reviewed before acceptance. This task was a maximum effort activity that imposed significant demands on the staff allocation and travel budget of the three offices, displacing other work such as some agency- priority crash investigations in SCI and a portion of safety defect screening and investigation activity in ODI.

3.0 METHODOLOGY

3.1 Incident Sources / Selection

Candidate incidents were selected from a variety of sources with the objective of identifying vehicles containing pre-crash- capable EDRs involved in alleged UA incidents with accessible pre-crash data. Accessibility covered several dimensions:

- **Geography:** Travel accounted for a significant portion of the time expended on a given inspection. To maximize the use of time and staff, inspections were prioritized in areas reasonably accessible to NHTSA operations. Practically speaking, this entailed a lot of east coast field inspections or geographical clusters around the country.
- **Physical:** the vehicle had to have experienced an impact that was severe enough[8] to enable the EDR algorithm but not so severe that the vehicle was destroyed. The vehicle also had to be in a location and condition amenable for physical access to the EDR. EDR access was dependent either on the vehicle having an intact electrical system and ignition keys to permit EDR access via the diagnostic link connector (DLC) or vehicle damage being such that it was possible for staff to access the EDR and effect a direct connection to the EDR itself.
- **Incident Timing:** Crash evidence is perishable. Memories fade, weather erodes physical evidence, vehicles are either repaired (EDRs discarded or overwritten), or are salvaged (EDRs discarded). Field inspection efforts were focused on the latest possible incidents.
- **Legal:** NHTSA obtained consent of the vehicle owner and the parties with custody of the vehicle and EDR. This usually entailed dialogue with the driver, their insurance company, salvage yard holding the vehicle and, in some cases, local law enforcement.

The field inspections originated from a number of different sources with consumer complaints to NHTSA or “VOQ”s[9] accounting for about half of the total (Table 2).

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[8] EDRs can be enabled from impacts such as curb strikes and potholes that are not severe enough to deploy the airbags. They are not however enabled by maximum effort braking or acceleration absent an impact.
[9] Vehicle Owners Questionnaire

Table 2: Field Inspections by Data Source

Source	Inspections	
Consumer Complaint	27	47%
Police Officer	10	17%
Toyota Data	7	12%
Media	6	10%
Insurance	3	5%
Attorney	2	3%
NASS PAR	2	3%
Crash Reconstructionist	1	2%
Total	58	100%

UA incidents alleged by all of the above sources were reviewed by ODI staff. As many as possible were followed up with telephone interviews. The telephone interviews were used to assure that the incidents met all of the criteria indicated above and to acquire background information about the incident and vehicle with which to arm the field inspectors.

3.2 Field Inspection Procedure

Field inspections were conducted individually and by teams of up to three persons. After collecting the information garnered from the screening interview, the field inspection team would arrange their trip and make every effort to conduct multiple inspections in one trip[10].

Inspection procedures varied for each visit based on logistics and the particular availabilities of the vehicle, scene, and involved persons. In general, the inspections included a scene assessment, physical inspection of the vehicle, interrogation of the vehicle control system with a Tech Stream diagnostic tool, recovery of the EDR data, and interview of any involved persons. Particular emphasis was placed on conditions in the driver's foot well, function / condition of the pedals, operation of the brake light switch, and accelerator voltage circuit integrity.

[10] The 58 inspections were carried out via 33 trips. One third of the trips (ten) accounted for over half (35) of the 58 inspections.

4.0 RESEARCH and ANALYSIS

4.1 Techstream

Techstream is Toyota's second generation interfacing software program used to capture a vehicle's on- board diagnostic (OBD) information. Access to the vehicle's OBD system gives the user access to state of health information for various vehicle control systems. Techstream devices were used where possible[11] in during field investigations to check the operational status of the vehicles control systems for damage or failure. If a failure was identified with a vehicle's sub-system its potential effect on the alleged UA condition was assessed.

Selected field inspection teams received Techstream devices by early May. Downloads are summarized in Table 3.

Table 3: Field Inspections by Techstream usage and DTC recovery

DTC's	Recovered	
DTC's Found	15	26%
No DTC's Found	9	15%
Not Gathered	34	59%
Total	58	100%

In all, 133 diagnostic trouble codes (DTC) were recovered from fifteen vehicles. Of those 64 DTC's were unique (Table 4). Codes ranged from ventilation system to component failures due to crash damage. The failure codes can be grouped into four classifications including B, C, P, and U codes. The first character identifies the system related to the trouble code P = Powertrain, B = Body, C = Chassis, and U = Undefined; although commonly used for module communications. All 133 codes listed as historical, current or pending were reviewed with staff members trained in automotive diagnostic troubleshooting in order to identify any possible sign of vehicle malfunction that could cause a UA event. Staff paid particular attention to any codes that interact with the vehicle's accelerator/throttle system. None of the codes recovered from the subject vehicles could be linked to a possible acceleration concern.

[11] Tech Stream data availability is highly dependent on the vehicle electrical system remaining intact

Table 4: Recovered Diagnostic Trouble Codes

DTC's	Recovered	
Body	32	50%
Undefined	14	22%
Powertrain	10	16%
Chassis	8	12%
Total	64	100%

4.1.1 Results

Tech Stream downloads were performed on only a portion of the 58 vehicles inspected the limited coverage was due in part to vehicle damage and limited availability of Techstream units.

4.2 Field Inspection Timing

Field inspections aimed at collecting pre-crash data from Toyota incidents in which one form or another of unintended acceleration was alleged were conducted from the beginning of March through early August 2010 (Table 5).

Table 5: Field Inspections by Inspection Date

Inspection Month	Inspections	Incremental	Cumulative
March	6	10%	10%
April	9	16%	26%
May	20	34%	60%
June	5	9%	69%
July	17	29%	98%
August	1	2%	100%
Total	58	100%	

After a period of training and practice in March and April, the pace of field inspections accelerated to average one per business day in May. The pace was reduced for analysis and review in June and then ramped back up throughout July, and then closed out. This time period represented intense activity and obligated a third of ODI's investigative and screening staff overall, with approximately 10% in the field at any given time during the months of May and July.

4.2.1 Results

Findings from the 58 field inspections were binned into one of four categories (Table 7). Further explanations of each are listed below. Tables listing all the cases by case number and outcome are enclosed in Report No. NHTSA-NVS-2011-ETC-SR11.

Table 6: Field Inspection Outcomes

Outcome	Inspections	
EDR Data Unavailable	6	10%
UA- Accel pedal entrapment	1	2%
Non-UA	12	21%
Pedal Misapplication	39	67%
Total	58	100%

4.3 EDR Data Unavailable- Six Incidents

EDR data were unavailable in six incidents. In five of these cases, no data were found within the EDRs. Physical evidence from those incidents suggests that the vehicles did not experience a severe enough impact to enable the EDR. A sixth incident vehicle contained an EDR whose data did not align with the crash reported by the driver. It did however contain data that were consistent with a less severe (non-UA) impact subsequent to repairs to the vehicle. It is believed that the EDR involved with the UA incident was removed and replaced as part of the extensive repairs needed to recover from that incident.

4.4 Accelerator Pedal Entrapment- One Incident

One incident (Case 15) turned out to be entrapment of an accelerator pedal by an all weather floor mat. This case was reported to NHTSA by an insurance company and involved a 2007 Lexus ES350 that was on an interstate highway approaching a long exit ramp (Figure 1). According to the driver, some jockeying for position was necessary that included a passing maneuver (accelerator application). The driver further indicated that after releasing the accelerator at the end of the passing

Figure 1: Case 15 Scene Overview

maneuver, he applied his brakes to slow the vehicle, using both feet at one point. He additionally maneuvered the vehicle against a guardrail in an unsuccessful effort to bring it to a stop. At the end of the exit ramp, the vehicle traversed a traffic light- controlled T intersection, left the roadway, struck a curb (deflating the right front tire), and landed in a marsh. The vehicle sustained significant frontal, undercarriage, and right side bodywork damage, and the driver experienced minor injuries. None of the airbags deployed.

The subject vehicle experienced at least two AE events during the incident, leading to two overlapping pages of EDR pre-crash data offset by approximately one second. Both are shown (Table 7) along with the 1 second offset to illustrate vehicle control status in the time period immediately preceding the crash:

Table 7: Case 15 EDR Pre-Crash Data Summarized (2 pages of overlapping data)

Case 15 Page 1 (Next Most Recent Bank (Precedes Latest by 1,080 ms))	**Time Interval**	**-5 sec**	**-4 sec**	**-3 sec**	**-2 sec**	**-1 sec**	**AE (-0.5s)**	
	Speed (mph)	63.4	57.2	52.2	51.0	51.0	47.2	
	Brake	ON	ON	ON	ON	ON	ON	
	Accelerator (V)	2.89	2.89	2.89	2.93	2.93	2.93	
	Engine (rpm)	5,200	5,200	3,200	3,600	3,600	4,400	
Case 15 Page 2 (Latest Bank)		**Time Interval**	**-5 sec**	**-4 sec**	**-3 sec**	**-2 sec**	**-1 sec**	**AE (-0.4s)**
		Speed (mph)	57.2	52.2	51.0	51.0	27.3	48.5
		Brake	ON	ON	ON	ON	ON	ON
		Accelerator (V)	2.89	2.89	2.93	2.93	2.89	2.15
		Engine (rpm)	5,200	3,200	3,600	3,600	4,400	3,600

Pre-crash data retrieved from the subject vehicle EDR shows the vehicle traveling at high speeds with a relatively high unchanging accelerator pedal voltage and consistent brake light switch status of "ON". Engine rpm were very high initially, descending somewhat at 4 seconds from final impact (Latest Bank). This corresponded with a reduction in vehicle speed that remained essentially unchanged for the remainder of the incident. Of note, the latest bank of data showed a dramatic[12] reduction of indicated vehicle speed at 1 second from final impact and then a similar rebound at AE (impact). This fluctuation corresponded with the initial impact (curb strike) and was likely the result of a momentary confinement of one of the front wheels.

[12] Taken at face value, the indicated deceleration and accompanying re-acceleration would both exceed 1g- well beyond the vehicle's performance envelope

Field inspection of the incident vehicle identified three intact tires, a deflated right front tire, and significant lower frontal impact damage. This damage pattern coincides with the terrain and two indicated impacts. Examination of the vehicle interior uncovered evidence that an OE Lexus all weather floor mat had constrained the accelerator pedal after the driver released it at the onset of the incident. When inspected, the subject vehicle's all weather mats were found in the rear seating area. Its OE carpeted floor mats were found secured properly in the footwells. Dirt patterns on the driver's carpeted mat indicated that the all weather mat was typically laid atop it in an (inappropriate) double stack configuration. Using the dirt patterns as a guide (Figure 2), it was possible to recreate the confined accelerator pedal. Examination of the vehicle showed no other indications of accelerator pedal, throttle body restriction or malfunction. Electronic outputs from the brake light switch and accelerator pedal were verified as within range.

Figure 2: Case 15 Floor Mats

4.5 <u>Non-UA- Twelve Incidents</u>

Not every incident reported as UA- related turns out to fit even the broad category of unintended acceleration reported in the media. Further examination of twelve such incidents revealed a number of different conditions.

Non-UA incidents include five of the six fatal incidents examined by the field inspections. All five of these cases were not witnessed and originated at higher vehicle speeds on open roadways. No testimony exists that would indicate driver intent with respect to acceleration or deceleration. It is likely that all occurred during steady state driving conditions.

Unexplained roadway departures at speed were associated with four of the non-UA incidents[13]. None of the information collected from these indicated attempts by the driver to manage a

[13] See NHTSA-NVS-2011-ETC-SR11; Cases 14, 38, 40, 48

runaway vehicle (e.g. heated brakes or evasive maneuver markings on roadways or terrain). Data collected from the EDR show little or no acceleration and no brake use of significance.

Three of the non-UA incidents[14] were rear impacts of vehicles stopped in the roadway. Two of these had drivers who reported deceleration efforts, while the other reported being stationary in the roadway when the vehicle lunged. All three reported using the brakes. All three cases have initiation speeds above 10 mph with either no brake use indicated or braking only one second or less prior to AE. Two of the three showed some accelerator application and modest engine rpm.

Case 12 was similar to the un-witnessed road departures except that it involved the subject vehicle crossing the centerline of a road during inclement weather to strike another vehicle head-on. The vehicle was unavailable for direct inspection but the EDR indicated no brake application.

Case 24 involved a subject vehicle traveling at high speeds in a residential development. The driver initially reported to police that the accelerator pedal stuck after the driver released it and that attempts to slow the vehicle with the service brakes and the parking brake were unsuccessful as it attempted to negotiate a left turn. The police accident report indicated that yaw marks left on the roadway showed no indication of park brake engagement. Review of the EDR data showed an early transition from full accelerator application to brake use (Table 8). Concurrent with that transition, the high engine rpm declined and the vehicle decelerated at close to its maximum rate of 0.8 g. The incident ended with the engine at idle.

Table 8: Case 24 EDR Pre-Crash Data Summarized

Time Interval	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec	AE
Speed (mph)	50.9	54.7	50.9	31.1	13.7	13.7
Brake	OFF	OFF	ON	ON	ON	ON
Accelerator (V)	3.01	0.78	0.78	0.78	0.78	0.78
Engine (rpm)	4,400	4,400	2,400	1,600	800	800

Circumstances surrounding Case 16 indicate a vehicle that failed to yield to traffic at a stop sign-controlled intersection. The incident began with brake application and almost 3 seconds of

[14] See NHTSA-NVS-2011-ETC-SR11; Cases 10, 43, 44

deceleration at 0.2g to approximately 5 mph, followed by a modest accelerator application, 0.1g acceleration and then impact. Engine speed always stayed at or below 2,000 rpm[15].

Case 31 was the only non-UA incident that included significant acceleration. It was included here because it is the only incident in which the driver clearly indicated an accelerator application with no attempt to slow down. Incident circumstances were that the driver was parallel parking the subject vehicle on a city street. During the parking maneuver, the vehicle (an SUV) appears to have gotten a rear wheel lodged against the curb, whereupon the EDR data[16] (Table 11) indicate that the driver applied the accelerator. After a two second period of rising engine rpm and no corresponding vehicle movement, the vehicle climbed the curb, and struck a building and several pedestrians.

Table 9: Case 31 EDR Pre-Crash Data Summarized

Time Interval	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec	AE
Speed (mph)	0.0	0.0	0.0	0.0	7.5	12.4
Brake	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator	OFF	OFF	OFF	FULL	OFF	OFF
Engine (rpm)	400	400	800	1,200	2,000	1,200

In addition to examining the scene, vehicle, and the EDR, the incident was reenacted to establish plausibility.

4.6 Pedal Misapplication

4.6.1 Pedal Misapplication Incidents

The bulk of the incidents (39) are characterized as pedal misapplication incidents based on information collected from the EDRs and the physical facts collected during the inspections.

Pedal misapplication- refers to a situation in which a driver intends to apply the brake and inadvertently applies the accelerator instead or, in some cases, applies both the accelerator and the brake at the same time (dual application). Pre-crash EDR data provides direct and objective

[15] 2,000 rpm is a typical engine speed expected for normal driving conditions.

[16] This was one of the earlier cases imaged with an early version of the EDR reader software that was unable to register accelerator pedal position voltage.

evidence of driver pedal application. Table 10 bins the 39 unexplained incidents by brake light switch status immediately prior to impact.

Table 10: Brake Application Indicated by EDR Pre-Crash Data

Brake Application	Inspections	
None	29	74%
Late	6	15%
Early / None	2	5%
Significant- midevent	1	3%
Dual	1	3%
Total	39	100%

EDR data for a majority of pedal misapplication incidents indicated no brake application whatsoever. An additional 15% showed a "late" brake application[17].

Only one incident in this category (Case 21) yielded EDR data indicating a significant brake application prior to collision. The vehicle owner had just entered the vehicle and was reversing out of a commercial garage parking space. After shifting into drive the vehicle accelerated rapidly down the garage ramp, attempted to make a left turn but overshot, striking a building. The driver stated placing both feet on the brake attempting to slow the vehicle. The EDR report (Table 11) shows full accelerator pedal application for the duration of the data collected, and a rapid rise in vehicle speed and engine rpm. A significant brake application was observed from -3 to -2 seconds commensurate with over a 6 mph speed reduction (0.2g of deceleration). This indicates that the vehicles brakes were used for only a portion of the event despite the accelerator being in full use throughout.

Table 11: Case 21 EDR Pre-Crash Data Summarized

Time Interval	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec	AE
Speed (mph)	14.9	23.6	28.6	22.4	31.1	31.1
Brake	OFF	OFF	ON	ON	OFF	OFF
Accelerator (V)	3.36	3.36	3.36	3.36	3.36	3.36
Engine (rpm)	2,400	3,600	4,400	3,600	5,200	5,200

Because the EDR showed an unchanging accelerator pedal position voltage of 3.36 throughout the pre-crash period, and because the driver apparently abandoned a significant mid-event brake

[17] Here, a "late" brake application describes the brake light switch status transitioning to "ON" at either -1 sec or AE. This timing / duration is insufficient to meaningfully slow the vehicle in a crash situation

application, the field inspection team performed additional circuit integrity checks to verify brake and accelerator. No abnormalities were identified.

Incidents were also binned according to accelerator pedal positions as indicated by EDR data. Table 12 summarizes the 39 pedal misapplication incidents according this category.

Table 12: Accelerator Application Indicated by EDR Pre-Crash Data

Accelerator Application	Inspections	
Ramping accelerator application	23	59%
Sustained accelerator application	12	31%
Acclerator spike	4	10%
Total	39	100%

Over three quarters of pedal misapplication incidents returned EDR data that showed significant accelerator application concurrent with no meaningful brake application. This was corroborated by other EDR data (engine rpm and vehicle speed) and physical evidence. Descriptions of Cases 33 and 30 illustrate many of the conditions found throughout all 39 cases of pedal misapplication examined in this project:

Case 33, which involved a 2009 Camry operated by a male driver in his mid- thirties intruded into a hair salon during daylight hours in late 2009 typifies the majority of UA crashes examined by ODI[18]. The driver had turned to enter the parking space from the lane of traffic and was about to come to a rest facing a shopping plaza storefront at the time of the incident. The driver reported having his foot on the brakes when the vehicle unexpectedly lunged forward, traversed the sidewalk, and intruded into a hair salon. After penetrating the brick and window façade, the subject vehicle traversed the waiting room area and came to a rest against the reception desk. The subject vehicle driver's left front tire deposited a streak of rubber on the floor and the driver reported that the engine was roaring even as his foot was on the brake. The incident was ended by the driver shifting the transmission into Park and shutting the engine off after the vehicle came to rest. The impact was insufficient to deploy the frontal airbags and the vehicle suffered minor damage,

[18] Consumer complaint data show that low speed in confined spaces- typically parking maneuvers account for a majority of UA crashes industry-wide, within Toyota products, and within the Camry model

Figure 3: Case 33 Incident Scene

The vehicle had received normal maintenance throughout its service life and had accumulated approximately 14,000 miles at the time of the incident. Neither the driver nor the vehicle's service history indicated prior engine control or brake concerns with the vehicle and it did not appear to have been involved in any prior crashes. Physical examination of the vehicle shortly after the incident showed no apparent concerns with the brakes, throttle, or accelerator pedal.

EDR data was extracted from the vehicle (Table 13). The incident began at very low speeds and engine rpm. Very low accelerator pedal use is indicated at -5 and -4 seconds. At -3 seconds, an increase in accelerator application is indicated along with commensurate increases in engine and vehicle speed over the next interval. The accelerator returns to idle at -2 seconds and then goes to full at -1 seconds, engine and vehicle speed increasing all the while. No brake application is indicated whatsoever. Vehicle airbags did not deploy and no one was injured as a result of the incident.

Table 13: Case 33 EDR Pre-Crash Data Summarized

Time Interval	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec	AE
Speed (mph)	3.7	3.7	3.7	9.9	13.7	19.9
Brake	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator (V)	0.86	0.82	0.98	0.78	3.71	1.37
Engine (rpm)	400	400	800	1,600	3,200	4,400

Pedal misapplication incidents are not confined to parking areas. Complaint data show additional incidents occurring at road speeds, typically in situations such as intersection approaches and stop and go traffic where a brake application is needed. Case 30 is one such incident.

Case 30 involved a 2007 Camry operated by a female in her fifties striking vehicles stopped in traffic ahead of her during the first half of 2010. The incident took place during daylight hours on a local road with a posted speed limit of 25 mph and on an ascending grade. The driver reported depressing the brake to decelerate and feeling the vehicle accelerate. She reported pressing the pedal harder, causing the Camry to accelerate harder and then strike vehicles stopped ahead of her. The impact was strong enough to deploy both frontal airbags in the Camry and caused injuries to its (restrained) driver as well as an occupant of one of the struck vehicles.

Figure 4: Case 30 Subject Vehicle

A Carfax report did not indicate any prior collisions. The vehicle, which had accumulated approximately 25,000 miles of service at the time of the incident, had received recall remedies to address sticky pedal and accelerator pedal entrapment.

EDR data was read from the vehicle. The first two seconds of EDR data indicate that the vehicle was traveling at a constant speed of 27 mph and show the accelerator pedal and engine returning to idle. Accelerator application jumped from idle to almost full application from -3 to -1 seconds, followed by increases in engine rpm. No brake application was indicated during the data recording period.

Table 14: Case 30 EDR Pre-Crash Data Summarized

Time Interval	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec	AE
Speed (mph)	27.3	27.3	26.1	26.1	27.3	31.1
Brake	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator (V)	0.90	0.78	1.41	3.28	3.75	0.78
Engine (rpm)	1,200	800	2,000	2,000	2,800	2,800

4.6.2 <u>Pedal Misapplication Circumstances</u>

Incidents were binned according to the vehicle model involved, initiation speeds, initiation maneuvers, and driver demographics. Here, the 39 pedal misapplication incidents found are binned to identify traits that may point to common factors.

Together, the MY 2007 – 2010 Camry / ES350[19] accounted for over half (21) of the vehicles found to have experienced pedal misapplication (Table 15).

Table 15: Vehicle Model/MY- Pedal Misapplication Incidents

Model	MY Range		Incidents	
Camry	2007	2010	16	41%
RAV4	2007	2010	6	15%
ES350	2007	2008	5	13%
Corolla	2009	2010	4	10%
Highlander	2004	2010	3	8%
RX400h	2006		1	3%
LS430	2004		1	3%
LS460	2008		1	3%
Sienna	2004		1	3%
Camry HEV	2007		1	3%
Total / Overall	2004	2010	39	100%

Twenty-four (61%) of the pedal misapplication incidents examined initiated at speeds of 15 mph or less (Table 16). All of these took place in a confined space such as a residential driveway or commercial parking lot. Those that initiated at the medium and high speeds[20] include circumstances where the driver appeared to intend to use the brakes to decelerate, usually on approach to an intersection.

Table 16: Location / Initiation Speed Distribution- Unexplained UA incidents

Space Type	Initiation Speed	Incidents	
Confined	Stationary	6	15%
	Low	18	46%
	Medium	5	13%
	High	0	0%
Roadway	Stationary	0	0%
	Low	0	0%
	Medium	8	21%
	High	2	5%
Total		39	100%

Expressing the data in terms of maneuvers, rather than initiation speeds (Table 17), parking maneuvers account for almost two thirds (24) of pedal misapplication incidents with parking

[19] Earlier models were not inspected because they lacked pre-crash EDR capability. The Avalon, another Toyota model frequently involved in UA incidents was omitted because it did not attain pre-crash EDR capability until very recently.

[20] Medium speeds are 15 – 45 mph; High speeds are in excess of 45 mph

space entry outnumbering parking space exit by a ratio of 2:1. In-traffic deceleration accounted for the next largest share (7), followed by Confined Space- Driving- Stop & Go (typically in parking facilities).

Table 17: Location / Initiation Speed Distribution- Unexplained UA incidents

Space Type	Initiation Maneuver	Incidents	
Confined Space	Entering Parking Spot	16	41%
	Exiting Parking Spot	8	21%
	Driving vehicle- stop&go	3	8%
	Stopped / Idling	1	3%
	Driving vehicle- steady	1	3%
In-Traffic	Decelerating	7	18%
	Driving vehicle- steady	2	5%
	Driving vehicle- stop&go	1	3%
Total		39	100%

Driver ages were collected during the field inspection activity (Table 18).

Table 18: Age Distribution- Unexplained UA incidents

Driver Age Range (Years)	Incidents	
20 - 34	2	5%
35 - 44	2	5%
45 - 54	4	10%
55 - 64	7	18%
65 - 74	8	21%
75+	16	41%
Total	39	100%

Pedal misapplication incidents were disproportionately experienced by older drivers, with thirty one (79%) involving drivers 55 years or older at the time of incident. Twenty-four (62%) of drivers were 65 years or older at the time of incident. A comparison of Camry ownership by age group to driver ages for the 16 pedal misapplication incidents for this model is displayed in Figure xx below.

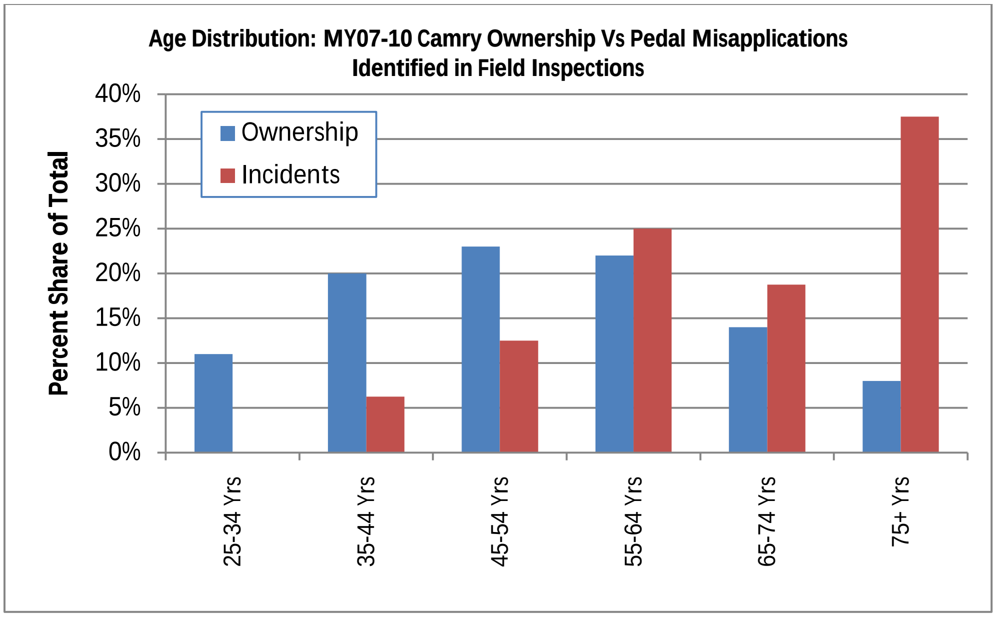

Figure 5: Camry Age Distribution: Ownership Vs Pedal Misapplication Incidents

4.6.3 Field Inspections in the Context of Broader UA Complaint Activity

Questions have been posed concerning the relatively small number of field inspections (58 total, 27 of which were prompted by VOQs) as compared to the thousands of consumer complaints received reporting UA in Toyota vehicles. The objective of the field inspection program was to examine incidents where UA was reported in Toyota vehicles and pre-crash EDR data was likely to be available so as to better rule out driver influence when searching for a vehicle- based safety defect. As noted earlier, several criteria were employed to identify incidents that represented the most effective use of finite resources. The influence of these criteria on the complaint screening process is illustrated in Figure x.

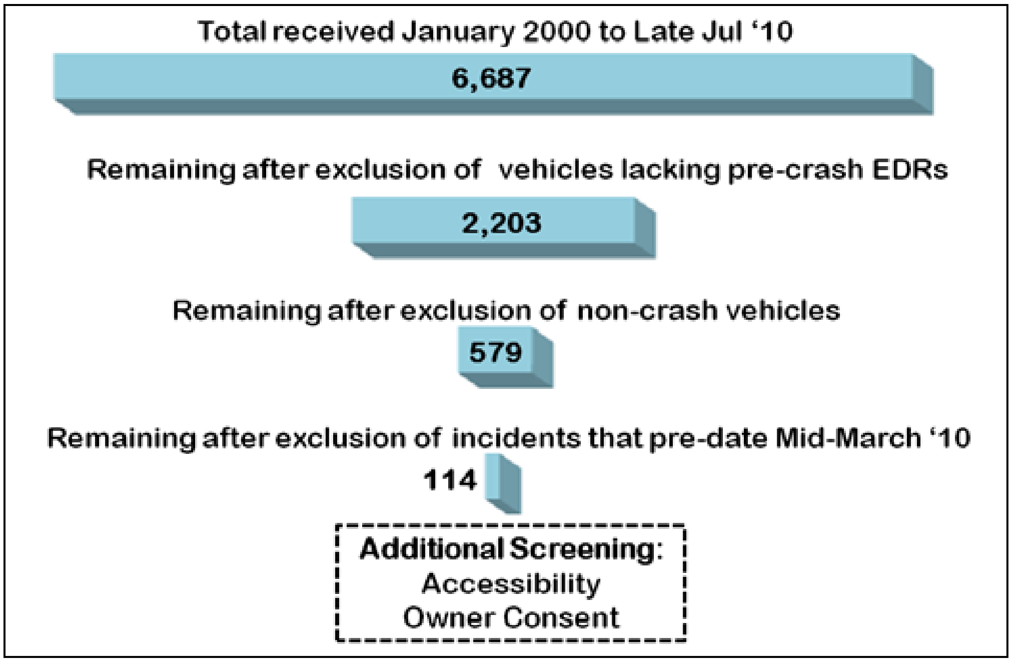

Figure 6: UA VOQ Traffic Compared to Field Inspection Screening

No UA condition code exists in ODI's VOQ database. However, it is possible to identify likely UA incidents with a keyword search based on the VOQ narrative. While the results of this search are broad and include some non-UA complaints, the search does capture a majority of likely UA VOQs. Applying these search terms to over 426,000 VOQs received from January 2000 to the end of July 2010, 6,687 VOQs were identified. Because the field inspection program focused on obtaining pre-crash EDR data, VOQs associated with vehicles lacking this capability were screened out. This left 2,203 VOQs meeting the UA keyword criteria in pre-crash EDR-equipped Toyota vehicles. In order to trigger a pre-crash EDR to capture data, a crash had to occur. Screening out non-crash VOQs reduced the available pool to 579 potential vehicles. VOQs concerning incidents that occurred on or after mid-March were selected from that group in order to obtain the freshest possible evidence. Some exceptions[21] to this practice exist but they were, by and large unique. Screening out incidents occurring prior to mid- March reduced the available pool to 114 VOQs.

[21] Six exceptions exist, reducing the number of VOQ-associated field inspections tied to the 114 to 21

The remaining VOQs were more closely scrutinized for relevance and accessibility. A total of twenty-two field inspections were conducted, all but one of which yielded EDR data[22]. It's important to note that the field inspection activity was resource-constrained and that given more staff or time, more of the incidents could have received visits. Accessibility in this case is combination of geography, timing, and office staff availability. Of the 92 remaining VOQs that did not lead to inspection, almost half (39) were not pursued because they were in a remote location. A quarter (25) of the VOQs was not pursued due to timing (program stand-down). An additional 13% (12) were not pursued because, in the judgment of staff, the crashes involved fell below the threshold needed to enable the EDR algorithm.

4.6.4 Discussion

Fifty- eight field inspections of vehicles involved in alleged UA incidents were conducted. Pre-crash EDR data- a prime objective of this activity was retrieved in 89% (52) of these inspections. Fully three quarters (39) of the 52 turned out to be pedal misapplication- drivers placing their feet on the accelerator pedal rather than the brake immediately prior to impact. A majority of these incidents initiated from stationary positions or speeds below 15 mph and were typically parking maneuvers—similar to patterns observed in overall complaint data (this topic will be addressed in greater detail in the next section. Pre-impact maneuvers such as parking space entry / exit and intersection approach suggest that drivers intended to apply the brake. In many cases, drivers were familiar with their vehicles. In some cases, the drivers indicated that they had their attention fixed on other tasks in addition to vehicle operation.

[22] One inspection involved a vehicle with a very light impact that was too new to connect the EDR reader. No further information was collected on this case.

5.0 CONCLUSION

NHTSA's field inspections of Toyota vehicles in 2010 did not provide evidence of any vehicle-based cause of UA of which NHTSA was previously unaware (One incident appeared to involve pedal entrapment by a floor mat.). The inspections indicated that many UA incidents continue to occur as the result of the driver's inadvertent application of the accelerator pedal rather than the brake or simultaneous application of the accelerator and brake. Of course, vehicle characteristics such as a pedal placement may have the effect of increasing the likelihood of pedal misapplication.