C20 Toyota® SUA: A Formal and Definitive Electronic SUA Examination Protocol

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The goal of this presentation is to show how the issue of the alleged Toyota® Sudden Unrequested Acceleration (SUA) has been the subject of media attention and intense Multi-District-Litigation (MDL). Various court protocols have been instituted in an attempt to standardize the examination of components, systems, and Event Data Recorder (EDR) event-records regarding the issue of the alleged SUA. This presentation teaches a method to amalgamate these protocols into a master procedure which specifies tests incorporating the three modes discussed above as possible for a specific Vehicle Under Test (VUT).

This presentation will impact the forensic science community by providing a tested and confirmed amalgamated master procedure that specifies tests incorporating the three alleged SUA vehicle test modes, such that the attendee will then be prepared for whatever field conditions he/she faces when encountering a vehicle subject to various court SUA protocols.

The issue of alleged Toyota® SUA has been the subject of media attention and intense MDL. Causes of alleged SUA can include mechanical, electrical, and computer control aspects. As a foundation to understand the technology involved, this presentation illustrates the architecture of the Toyota® Electronic Throttle Control systems (ETCS-i). This architecture includes an electronic accelerator function (Figure 1) and an electronic throttle function (Figure 2). The electronic accelerator provides a dual signal input to an Electronic Control Module (ECM) which represents an electrical accelerator-position-analog of the % pedal requested by the operator. The ECM acts on that signal, modulated by engine temperatures, current RPM, current vehicle speed, and other factors to provide a requested throttle angle to the electronic throttle. The electronic throttle actual angle is fed back via a dual signal Throttle Position Sensor (TPS), which produces an electronic throttle-position-analog to the ECM, thus forming a throttle closed-circuit feedback loop. Figure 3 is an overview schematic of this system. Additional to the primary throttle control system, the vehicle cruise control system is implemented within the ECM and it can also modulate the electronic throttle control.

In a crash event, the operating status of the vehicle is also monitored by an Event Data Recorder (EDR), and that is included in the protocol.

Examinations of these systems can happen in three modes:

1. Static component testing, no power to vehicle, including external EDR data retrieval.
2. Dynamic powered engine-not-running tests, including *in situ* EDR data retrieval.
3. Dynamic powered engine-running tests, including road tests

In Static Mode: the individual components are characterized individually by disconnecting them from the system to determine voltage and/or resistance outputs (throttle-analog and accelerator-analog) versus physical input or position. If power cannot be applied to the vehicle, the EDR data can be retrieved in a stand-alone mode.

In Dynamic Powered Engine-Not-Running Mode: the super system (accelerator, ECM, throttle) is monitored at its interface points and then actuated electrically to characterize the running voltages at the interfaces of all these components in a dynamic sense. This includes simultaneous time line recordation of CAN bus PID parameters, analog voltage parameters, and physical component positions (via synchronized four-channel video). One part of these tests is known as a "throttle-sweep," where the accelerator is actuated in fast, slow, and pulse modes to check for the compliant operation of the throttle vs. accelerator, while monitoring the above parameters. With power applied to the vehicle, the EDR data can be usually be retrieved via the normal SAE J1962 diagnostic port.

Figure 4 is an overview schematic detailing the interfaces required to accomplish the engine controls master procedure monitor points. Note that in order to accommodate a wide variety of vehicle models, the protocol includes the use of Insulation Displacing Connectors (IDC) which allow adaption to each vehicle version of interest.

In Dynamic Powered Engine-Running Tests, Including Road Tests Mode: the super system (accelerator, ECM, throttle) is monitored as above, but additional CAN bus parameters are recorded (Engine RPM, vehicle speed, brake apply functions, coolant temperature, etc.). Before such tests, it is assumed that all EDR data has been retrieved.

Generally, serious case vehicles are operationally damaged, and various court protocols have been instituted in an attempt to standardize the examination of ETCS-i components and systems, and EDR event-records on these vehicles. Thus, the application of protocol modes is vehicle condition-dependent. This presentation shows key portions of these protocols and then provides an amalgamation of these protocols into a Toyota® SUA investigation master procedure which provides for tests incorporating the three modes discussed above as possible for a specific VUT.

One of the key aspects of an alleged SUA investigation is the retrieval and interpretation of EDR data. As is commonly understood, the EDR function is incorporated into the SRS ECU. Aside from recording internal signal parameters (acceleration, etc.), the SRS ECU acquires PID parameters (braking, vehicle speed, engine RPM, throttle angle, etc.) from the CAN bus and that is the basis of an "event record." The correct/incorrect operation of the ETCS-i system is one of the keys to assessing the reliability of the EDR data.

So, the application of the ECTS-i portion of the master procedure can serve to confirm or cast doubt upon the EDR recorded event-record.

An SUA investigation, using this master procedure, is illustrated with examples of simultaneous timeline observation and documentation of analog parameters, CAN PID parameters, and multi-channel video recordation of mechanical operations versus those electrical parameters. Additionally, this presentation includes illustrations and discussion of EDR data, control pedal measurements, ECM data, ABS data, and ESC data.

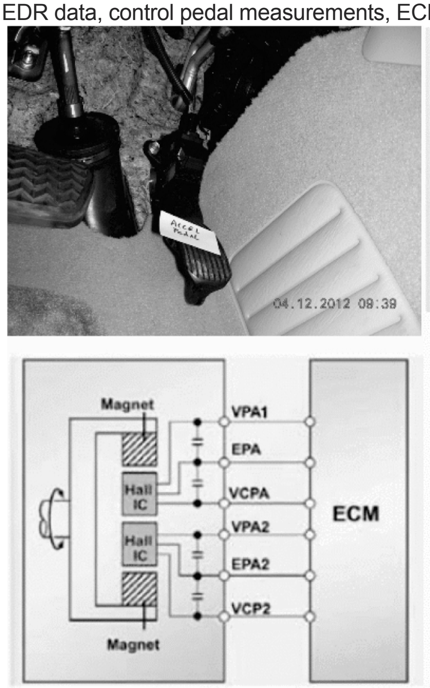

Figure 1. Electronic accelerator

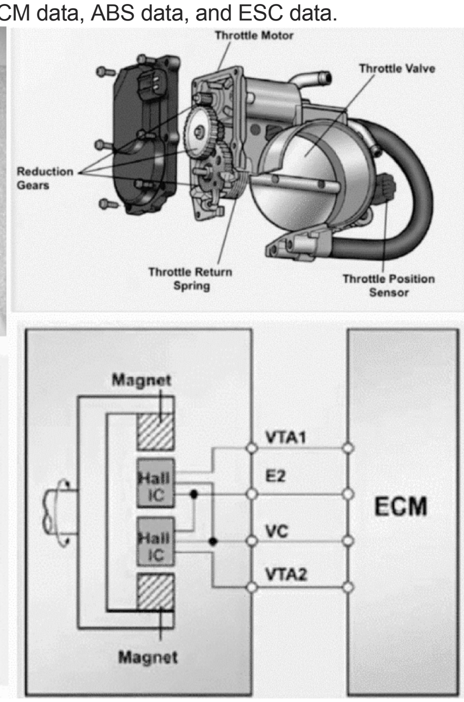

Figure 2. Electronic throttle.

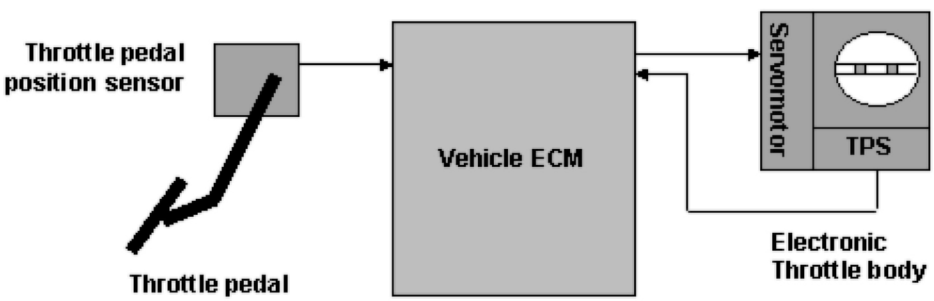

Figure 3. System schematic.

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Instrumentation Plan for Characterizing Toyota Vehicles Alleged to have Experienced an SUA Incident

Fabricate vehicle harness interceptor breakout boxes to allow independent monitor of analog signals and CAN bus parameters via independent D/A system on a common timeline. Obtain components to fabricate interceptor harness for Electronic-Accelerator & Electronic Throttle component pairs . The use of interceptor harnesses and J1962 interfaces facilitate vehicle parameter capture with no significant disturbance of on-vehicle OEM operating systems. The protocol includes Insulation Displacing Connectors (IDC) which allow adaption to each vehicle version of interest.

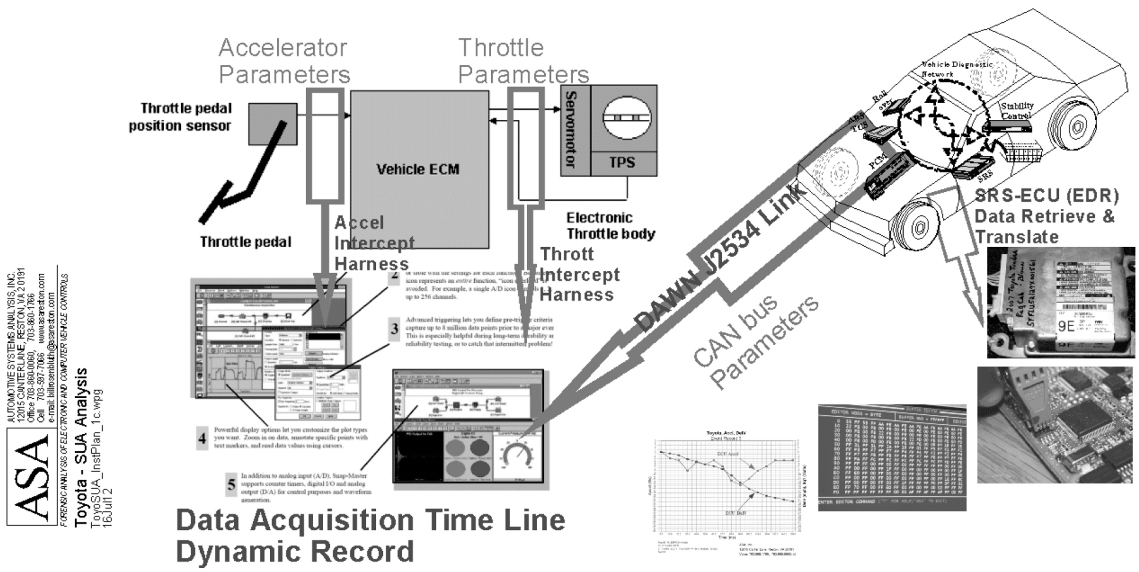

Figure 4. Overview system schematic.

Toyota® SUA, Toyota® MDL, Sudden Acceleration