TRANSPORTATION RESEARCH BOARD

January 2012

TRB REPORT IN BRIEF

# The Safety Promise and Challenge of Automotive Electronics

## *Insights from Unintended Acceleration*

From summer 2009 through spring 2010, reports of drivers claiming that their cars had accelerated unintentionally captured national media attention. The nature of the claims varied. Some involved moving vehicles that did not slow down as expected when pressure on the accelerator pedal was released. Others involved vehicles that sped up abruptly with high engine power from a stopped position or while moving slowly. Some drivers described fluctuations in engine idling, hesitation, and shuddering. Degraded or failed braking capacity was often asserted along with the unintended acceleration. Toyota Motor Corporation, whose vehicles were the subject of many of the complaints, issued recalls for millions of vehicles to address accelerator pedals that could be entrapped by floor mats and to fix pedal assemblies that were susceptible to sticking. In the wake of the highly publicized Toyota recalls, many individuals with expertise ranging from human factors to electronics hardware and software offered theories on other possible causes. The electronics in the automobile throttle control system were at the center of many of these theories.

During the peak of the unintended acceleration controversy in March 2010, the National Highway Traffic Safety Administration (NHTSA) enlisted the National Aeronautics and Space Administration (NASA) in an in-depth examination of the potential for vulnerabilities in the electronics of the Toyota electronic throttle control systems (ETCs). NHTSA also requested a National Research Council (NRC) study to review investigations of unintended acceleration and to recommend ways to strengthen the agency's safety oversight of automotive electronics systems.

The NRC committee's findings reveal how the electronics systems being added to automobiles present many opportunities to make driving safer but at the same time present new demands for ensuring the safe performance of increasingly complex vehicle technologies. The safety assurance demands pertain both to the automotive industry's development and deployment of electronics systems and to NHTSA's fulfillment of its safety oversight role. With regard to the latter, the committee recommends that NHTSA give explicit consideration to the oversight challenges arising from automotive electronics and develop and articulate a long-term strategy for meeting them. A successful strategy will reduce the chances of a recurrence of the kind of controversy that drove NHTSA's response to questions about electronics causing unintended acceleration. As electronics systems proliferate to provide more vehicle functions, neither industry nor NHTSA can afford such recurrences—nor can motorists.

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## WHAT IS THE ISSUE?

NHTSA, the U.S. regulatory agency that oversees federal standards for motor vehicle safety and monitors the fleet for safety defects, received an increase in driver complaints of unintended acceleration involving certain Toyota vehicles beginning in 2007. NHTSA investigated the complaints and attributed them to drivers inadvertently pressing the accelerator pedal instead of the brake and to pedals that were obstructed by floor mats or that were prone to sticking. NHTSA's investigations did not uncover any reason to suspect that the cause was faulty electronics in the vehicles' ETCs. The investigations led NHTSA to decide against undertaking more in-depth investigations of possible faults in the ETCs of Toyota vehicles that had been recalled for pedal entrapment and sticking.

Faced with persistent questions about the basis for this decision, however, NHTSA commissioned this NRC study and another by a team of engineering and safety specialists from NASA in early 2010. A detailed analysis of Toyota's ETC led NASA to conclude that vulnerabilities and faults in the ETC represented an implausible explanation for the high-power unintended acceleration reported in consumer complaints. The NASA investigators further confirmed NHTSA's conclusion that the ETC could not disable the brakes so as to cause the immediate and catastrophic loss of braking capacity, as often reported by drivers experiencing unintended acceleration. Not having produced evidence of a safety-related defect in Toyota's ETC, NHTSA elected to close its investigation into this system as a suspect cause of reported cases of high-power unintended acceleration and stood by its earlier conclusions attributing these events to pedal misapplication, entrapment, and sticking.

Because of NASA's work, the causes of unintended acceleration by Toyota vehicles are clearer today than they were in 2010. Nevertheless, whether the technical justification for suspecting electronics systems in this particular instance warranted the attention given to them and the commissioning of the detailed NASA study is a question that deserves consideration in view of the potential for electronics systems to be implicated in many other safety issues as their uses proliferate.

## WHY IS THIS REPORT IMPORTANT?

The NRC committee finds NHTSA's decision to close its investigation justified on the basis of the agency's initial defects investigations, which were corroborated by its follow-up analyses of thousands of consumer complaints, examinations of event data recorders in vehicles suspected to have crashed because of unintended acceleration, and the results of NASA's study. However, the committee found it troubling that the concerns associated with unintended acceleration evolved into questions about electronics safety that NHTSA could not answer convincingly. ETCs are simple and mature technologies compared with the newer electronics systems being developed. As more complex and interacting electronics systems are deployed, the prospect that vehicle electronics will be suspected and possibly implicated in unsafe vehicle behaviors increases. The actions recommended in this report are intended to aid NHTSA in preparing for a future in which it will need the capacity to detect possible defects in these complex systems, assess their causes and proposed remedies with confidence, and make prudent decisions about when to seek the technical assistance of outside experts such as NASA.

## STUDY SCOPE

NHTSA requested this NRC study of how the agency's regulatory, research, and defects investigation programs can be strengthened to meet the safety assurance and oversight challenges arising from the expanding functionality and use of automotive electronics. NRC appointed a 16-member committee of experts tasked with giving special consideration to NHTSA's recent experience in responding to concerns over the potential for errant electronics to be the cause of reported cases of unintentional acceleration. The committee examined NHTSA's initiatives on unintended acceleration and reviewed the agency's regulatory, research, and defects investigation programs more generally, giving attention to their effectiveness in overseeing the safe performance of automotive electronics.

## FINDINGS

The committee found that electronics systems have become critical to the functioning of the modern automobile. Proliferating and increasingly interconnected electronics systems are creating opportunities to improve vehicle performance, safety, and reliability as well as demands for addressing new system safety and cybersecurity risks. By enabling the introduction of many new vehicle capabilities and changes in familiar driver interfaces, electronics systems are also presenting

challenges for system design. Automotive manufacturers visited during this study explained how they implement many processes during product design, development, and manufacturing intended to ensure that electronics systems function safely and interact effectively with drivers.

Despite these manufacturer efforts, the growth in automotive electronics alone will mean that NHTSA's Office of Defects Investigation (ODI) can anticipate that an increasing share of its time and resources will be devoted to recognizing and investigating potential defects involving electronics systems and to assessing the corrective actions proposed by manufacturers for recalls involving these systems. Failures associated with electronics systems—including those related to software programming, dual and intermittent electronics hardware faults, and electromagnetic disturbances—may not leave physical evidence to aid investigations into observed or reported unsafe vehicle behaviors. Similarly, many errors by drivers using or responding to new electronics systems may not leave a physical trace. The absence of physical evidence has complicated past investigations of incident causes, such as those of unintended acceleration, and may become even more problematic for ODI as the number, interconnectivity, and complexity of electronics systems grow.

A challenge facing NHTSA is to further the use and effectiveness of electronics technologies that can aid safe driving and mitigate hazardous driving behaviors and to develop the capabilities to ensure that these technologies perform their functions as intended. NHTSA regularly updates a multiyear plan that explains the rationale for its near-term research and regulatory priorities. However, the plan does not communicate strategic considerations, such as how the safety challenges arising from the electronics-intensive vehicle may require new regulatory, research, and defects surveillance and investigative capabilities.

## RECOMMENDATIONS

As vehicles become even more dependent on electronics systems for their critical functions, the type and nature of the safety demands placed on NHTSA's regulatory, research, and investigation programs will need to keep pace with the growth in electronics systems. The committee offers a series of recommendations intended both to support industry's efforts to ensure the safe performance of vehicle electronics systems and to strengthen NHTSA's ability to identify and respond to safety problems arising from deficiencies in these systems.

The committee recommends that NHTSA become more familiar with and engaged in standard-setting and other efforts involving industry that are aimed at strengthening the means by which manufacturers ensure the safe performance of their electronics systems. Such cooperative efforts represent an opportunity for NHTSA to obtain a stronger understanding of how manufacturers seek to prevent safety problems while helping agency personnel gain technical knowledge about the electronics systems being added to vehicles and the strategies used by manufacturers in ensuring their safe operation. The committee recommends that NHTSA collaborate with industry in conducting human factors research that will help inform manufacturers' decisions about how best to design system interfaces with the safe performance of the driver in mind.

To obtain access to additional technical expertise, the committee recommends that NHTSA convene a standing technical advisory panel comprising individuals with backgrounds in the disciplines central to the design, development, and safety assurance of automotive electronics systems, including software and systems engineering, human factors, and electronics hardware. NHTSA will be able to consult this expert panel on relevant technical matters that arise with respect to all of the agency's vehicle safety programs, including regulatory reviews, defect investigation processes, and research needs assessments.

The committee recommends that NHTSA undertake a comprehensive review of the capabilities that ODI will need in monitoring for and investigating safety deficiencies in electronics-intensive vehicles. The review should consider how agency research can be used to strengthen ODI's capabilities, particularly the detail, timeliness, and analyzability of the consumer complaint and early warning data that are so important to its defects surveillance and investigation responsibilities. The committee recommends that NHTSA strive to make electronic event data recorders commonplace in all vehicles, which will further assist ODI investigators in determining the causes of vehicle crashes. The utility and feasibility of equipping vehicles with more advanced recording systems that can log a wider range of data are identified as areas deserving further study.

At a more fundamental level, the committee concludes that NHTSA needs to give explicit consideration to how developments in automotive electronics are creating new safety challenges that will necessitate changes in the scope, direction, and capabilities of agency regulatory, research, and defect investigation programs. Accordingly, the committee recommends that NHTSA initiate a strategic planning effort that takes into consideration the safety challenges resulting from vehicle electronics and that gives rise to an agenda for meeting them. In the committee's view, it is vital that the planning be (*a*) prospective in considering the safety challenges arising from the electronics-intensive vehicle, (*b*) introspective in considering the implications of these challenges for NHTSA's vehicle safety role and programs, and (*c*) strategic in guiding critical decisions concerning matters such as the most appropriate agency regulatory approaches and associated research and resource requirements.

The committee further recommends that NHTSA place development and completion of the strategic plan as a top goal in its coming 3-year priority plan. NHTSA should communicate the purpose of the planning effort, define how it will be developed and implemented commensurate with advice in this report, and give a definite time frame for its completion. The plan should be made public so as to guide key policy decisions—from budgetary to legislative—that will determine the scope and direction of the agency's vehicle safety programs.

The long-term importance of strategic planning is obvious: the technological transformation of the automobile will continue, and being prepared for more safety concerns that arise rather than reacting to them will become increasingly important. The committee observes that NHTSA researchers are working with the automotive industry, universities, and other government agencies to examine future crash avoidance concepts such as vehicle-to-vehicle and vehicle-to-infrastructure communications systems. These systems will enable even greater vehicle autonomy and necessitate advancements in vehicle electronics that will go well beyond any systems now being deployed. By engaging in strategic planning on an ongoing basis, NHTSA will be in a better position to meet the safety demands that such technological advancements are likely to bring.

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**This report brief was prepared by the National Research Council on the basis of the committee's report.** Permission granted to reproduce this brief in its entirety with no additions or alterations. *The Safety Promise and Challenge of Automotive Electronics: Insights from Unintended Acceleration* is available from the Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-3213; fax 202-334-2519; or e-mail TRBsales@nas.edu).



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