

YOUR CAR COULD TAKE OFF BY ITSELF

SUDDEN ACCELERATION IS NOT A MYTH

Samuel J. Sero BSEE, P.E.
Renaissance Engineering
Forensic Engineers

Abstract: Sudden or unwanted acceleration events do occur. They are caused by known electromagnetic effects that are integral to the electrical and electronic design of the vehicle. This article is a synopsis of the author's 20 years of experience in investigating this condition.

INTRODUCTION

"I just got into the car, started it up, placed my foot on the brake and shifted into gear. When I took my foot off the brake the car just took off." In all too many of these events the mechanism by which the event ends is catastrophic. The tragedy of deaths that should not have occurred, lives ruined by devastating injuries, and even lives ruined by unwarranted criminal charges and incarceration are typical results of sudden acceleration events.

This simple statement describing a sudden acceleration event has been repeated thousands of times since 1982. Why 1982? This was when the mass changeover from carbureted to fuel injected engines took place. With this change came the mass use of the electronic cruise control.

The auto manufacturers would have everyone believe that all sudden accelerations are caused by the driver's pedal misapplication. The victims who have experienced a sudden acceleration and those who know the science know that

sudden accelerations happen due to design defects.

I have been investigating sudden acceleration events for nearly twenty years. Over this time I have heard the representatives of the auto industry try to spin the pedal misapplication story to fit what they want and cover themselves. They do it even when it contradicts what they have said in the past, or defies logic and science.

SUDDEN ACCELERATION CAUSATION

Auto manufacturers admit that only two mechanisms can cause a vehicle to accelerate; the driver's foot on the accelerator and the cruise control. Prior to the advent of the electronic fuel injected vehicle with cruise control the only reported events similar to Sudden Acceleration were those of vehicles which had throttle valves that were stuck open due to a mechanical bind while moving. These were actually failures to decelerate caused by mechanical binding of the throttle valve or its linkage. These incidents were few and far between and received little or no publicity. It wasn't until the Audi sudden accelerations occurred that any real notice was taken of the problem. The Audi vehicles involved in the incidents all had electronic fuel injected engines and electronic cruise controls. This aspect of the vehicle was never truly investigated and Audi chose to explain the events by an

improper placement of the brake and accelerator pedals.

The electronically controlled cruise control is a mechanism by which the speed of a vehicle is maintained by a small "computer". This device is actually a decision maker based upon the comparison of an input desired speed to the actual speed of the vehicle. The computer then adjusts the speed of the vehicle by opening or closing the throttle valve. This open/close function is accomplished by a mechanical cable pull, vacuum or motor controlled, or by a motor connected directly to the throttle arm, drive-by-wire. In a drive-by-wire system, all throttle function is controlled by this motor.

To this day sudden acceleration events are still occurring. They are beginning to proliferate in the drive-by-wire vehicles, a change that has made it possible for defects to arise in which the normal driving operation to pull open the throttle causes these events without operator input. Toyota, one of the first manufacturers to adopt drive-by-wire, has over 600 reported incidents of sudden acceleration alone. One need only go to the Office of Defects Investigation web site under NHTSA to find these reports and reports on other vehicles.

Drive-by-wire represents a regression back to the integrated cruise control system. Ford found that these integrated speed control equipped vehicles had 6 to 10 times the events than vehicles with stand alone cruise controls. The integrated variable speed controller (IVSC) as Ford called it was their first attempt to combine the cruise control with the electronic engine controller (EEC). Ford basically added the cruise control integrated circuit to the printed circuit

board of the EEC. This allowed them to eliminate the sensors for the cruise control and have the cruise function off of the sensors for the engine control, a money saving decision. In effect, it moved the cruise control from being a ten wire device to being a sixty or more wire device and increased the number of sudden acceleration events by 6 to 10 times in the vehicles so equipped.

Drive-by-wire combined with the increase in number and complexity of electrical and electronic devices with their numerous interconnections and lack of adequate EMI protection means that not only will sudden accelerations continue but numerous other electronic anomalies will occur. These latter have already been manifested in air bag, ATC (automatic traction control) and ABS (anti-lock braking system) malfunctions, and roll over prevention control malfunction.

It is admitted by the auto industry that these EMI fault aspects will leave no trace of their occurrence. This is the same finding that was made by the aircraft industry, medical electronics industry, radio operated devices such as cranes industry, and even the wheelchair industry. EMI is not a new problem, but as predicted in the 1975 NHTSA (National Highway and Traffic Administration) EMI evaluation document, the increased use of electrical and electronic components in vehicles has led to increased EMI problems.

The one question that always arises regarding any investigation of sudden acceleration as it is caused by EMI is "Can you reproduce it?" The answer is that no one can. No more than Boeing or any other aircraft manufacturer was able to reproduce the EMI effects on their

navigation systems by cell phones and computers. They tried and spent millions finally deciding that the best course of action was to design out the possibility of this interference up front and protect against it happening. They have employed such techniques as isolation of critical circuitry, coaxial conductors, twisted pair conductors, shielding techniques and redundant circuitry. These are all techniques well known to the auto industry but considered too costly to implement.

The reason the testing for reproduction can't or won't be done is because of its scope. In the case of the vacuum based cruise control the unit itself has 11 wires leading into it which are routed into a wiring harness containing as many as 60 more wires. Given just an on and off value of current carrying for each wire there are from 2^{11} (2048) to 2^{71} (2,360,000,000,000,000,000,000) possible combinations of signals at any given instant in time. Although each individual wire has the simple condition of being either on or off when in the on state each wire contributes to the conduction and radiation problems associated with EMI. Each wire will not only conduct its own signal but also whatever is being conducted by devices directly connected to it on interconnected wiring and by signals received by radiation of EMI from other wires and devices. This same huge number of possibilities occurs in the stepper motor cruise control. In the drive-by-wire system the range goes from 2^{50} (app. 1,120,000,000,000,000) to 2^{100} (app.1,250,000,000,000,000,000,000,000,000,000) depending upon the vehicle. Given this vast, nearly infinite, number of possible signals it is no wonder that testing is not immediately fruitful. This type of testing is not economically feasible.

MANUFACTURERS ADMISSIONS

The Ford Motor Company has defined the mechanisms by which an unwanted opening of the throttle, a sudden acceleration, can occur in one of their Fault Tree Analysis (FTA) documents. In fact this FTA became the basis of a 10 million dollar study that Ford initiated following an upsurge in sudden acceleration reports when the cruise control was integrated into the electronic engine controller. Ford determined that six mechanisms could cause a sudden acceleration:

1. Operator
2. Mechanical binding
3. Mechanical faults in the intake manifold
4. Stuck throttle
5. Variable speed control, binding of mechanical parts
6. Variable speed control electrical

The first consideration of these possible faults is that other than the operator all of them are the fault of the vehicle. More importantly all of the vehicle faults have occurred in Ford vehicles.

Mechanical binding of the throttle control cable from the cruise control servo has occurred and is still occurring. The lost motion attachment of some of the Ford products has such small clearance that routine engine filth will accumulate inside it and bind the cable.

Mechanical faults in the intake manifold are really cracks in the intake below the throttle, these are also vehicle defects. Intake manifold defects can reduce

the vacuum in the intake manifold which directly correlates to braking efficiency.

Ford has had a stuck throttle problem caused by excessive carbon deposits on the throttle plate. This causes the throttle plate to stick closed. The operator must apply excessive force to the accelerator pedal to "break" the bind and release it. In so doing the vehicle takes off because the throttle is opened so far so rapidly. This problem has created accident events in moving vehicles where the throttle is released and then sticks, when the operator again tries to accelerate, the plate is sticking and extreme force is required to free it and rapid acceleration occurs.

Variable speed control mechanical faults have occurred in which the throttle actuation cable has bound up in the take up reel of the servo motor.

The last category, variable speed control electrical, encompasses all of the electrical aspects of the cruise control system. This includes all aspects of electromagnetic interference. The random nature of these events has led Ford to state in its Failure Mode Effects Analysis (FMEA) of the stepper motor cruise control - that because the loss of electromagnetic compatibility (EMC) caused sudden acceleration is random and leaves no trace nor can be duplicated no further actions will be taken in this regard.

Whenever Ford or any auto manufacturer has been confronted with their FMEA's they make the claim that they are simply hypothetical things that can happen. In Ford's case and in my experience also with other auto

manufacturers these so called hypothetical conditions are reality.

THE UPDEGROVE STUDY

As mentioned previously, the Ford FTA was the basis for a massive investigation by Ford of over 2800 sudden acceleration events. Recognizing that the electronic aspects would leave no trace the concept was to apply a process of elimination approach. A questionnaire designed to use this approach was developed and applied to these 2800 plus vehicles. The result of this investigation was that only approximately 1% of the events could even marginally be ascribed to the operator. The remainder had no explanations under any of the five non-electric causations. Instead of following the trail of the electronic indication, Ford management chose to close the investigation and not make its results known to NHTSA.

The Updegrave study did show that there was no common demographic associated with a sudden acceleration. It disproved the contentions made by the auto industry that SA events are concentrated around elderly drivers, new drivers and drivers unfamiliar with the vehicle. The events occurred across all demographics, all vehicle models, all vehicle ages and miles of use, from brand new to in excess of 100,000 miles --- the only things that the vehicles had in common was being fuel injected with cruise control, and their hazardous behavior.

DEBUNKING THE AUTOMAKERS' EXPLANATIONS BRAKES WIN SO PEDAL ERROR IS PROVED

No braking system ever designed was done so with a design parameter of stopping the car with the throttle applied, let alone while at wide open throttle. The vehicle may eventually stop under this condition, or not depending on the braking system and the brake condition, but will the stop be from the brakes or from impact with a stationary object or another vehicle? There is the added problem that the vacuum assist required for power brakes is no longer available under the wide open throttle condition. This means that the vehicle has only manual braking. Manual braking is a condition in which if a vehicle could be brought to a stop under the application of 40 pounds of force with vacuum assist it will take upwards of 175 pounds of force without vacuum assist. This condition has been verified by NHTSA, my and other's independent testing, and by a Ford engineer who couldn't stop his runaway Explorer at wide open throttle, and another Ford expert, who needed more than 175 pounds of force to stop a vehicle at wide open throttle.

NO HUMAN FACTORS STUDIES SUPPORT DRIVER ERROR AS AN EXPLANATION

The auto people preach that the brake always wins, yet the brake system was not designed to stop the car with the throttle held wide open. By virtue of this misdirection they make the leap to the statement that since the brakes always win the driver must have been on the accelerator pedal or the vehicle would have stopped.

Let's look at this misdirection a lot closer. In the annals of braking misapplication investigation done by human factors experts, including those hired by Ford, the only time a pedal misapplication

has occurred is in a moving vehicle and under a panic condition. It is extremely difficult to see how this applies to a vehicle that is stopped and just beginning to move from a parked position, the condition of over 85% of the sudden acceleration events reported. When this little misdirection doesn't work the next trick is to say the operator had one foot on each pedal. Aside from the fact that the auto people have tried to accuse professional drivers, chauffeurs, police, military, and even people who work for the auto industry of this, there is one other important issue that dispels this misdirection. One test that can be run on any vehicle and it will always prove true is that if the brake and the accelerator are both pushed to the floor at the same time the brake will always hold. Experts hired by the auto industry have tried to use this test as some form of absolute proof that the brake always wins. In a stopped vehicle, if both pedals are pushed simultaneously, the vehicle will not go anywhere. This is a contrary condition to the original intent of getting in the vehicle to go somewhere. No driver who has experienced a sudden acceleration has ever done this. Let's look now at the equally absurd story of one foot pushing both pedals. First of all, this contradicts the whole design intent of the pedals which is to eliminate this possibility. All brake and accelerator pedals are separated horizontally and vertically to eliminate this possibility both by the spatial arrangement and by the physical feedback of each pedal. Years ago Audi used the easiest possible excuse and said that their pedal placement was the cause of the reported incidents of sudden acceleration. This was not the case and no in depth investigation was made into the cruise control and electronic malfunction aspect. A final pedal story is

that both feet are on the accelerator pedal. I can only say to the reader, try this yourself and see if it makes any sense. The only way for anyone to put both feet on the accelerator pedal is with one on top of the other.

THE DUMP VALVE WILL SAVE THE DAY

The concept of a dump valve, a secondary mechanical device to relieve vacuum when the brake is depressed, has only one reason to exist. This sole reason is in case of a sudden acceleration event. Ford has had their expert attest to this fact under oath in court. Let's look at just how this device does function since the auto industry has tried to use it as a defense against sudden acceleration claims. Their defense is that if a sudden acceleration were to occur then all the driver needs to do is hold on the brake. They never inform the driver of having to hold on the brake or of the fact that a sudden acceleration could occur. Pumping the brake, a common occurrence when a driver is trying to control a vehicle which is out of control, will only work to close and open the throttle valve. The fact that the sudden acceleration should never have occurred at all is blatantly ignored.

THE BRAKE PRESSURE SWITCH WILL SAVE THE DAY

When the change was made from the vacuum based cruise control to the stepper motor servo the electromagnetic clutch in the servo was energized the moment the vehicle was started. This was done to eliminate a close in control of the clutch, a cost saving feature. Like the dump valve this device only functioned to relax the pull on the throttle if and only if the brake was held on. This device had two

other drawbacks, the pressure required in the master cylinder to activate it, and it was prone to catch fire.

THE BTSI

In conjunction with the myth of driver error, the auto manufacturers went to the installation of the Brake Transmission Shift Interlock (BTSI). This device was to insure that the driver's foot was on the brake in order to shift the vehicle into gear. Let's just analyze this concept for one moment. If the BTSI was to stop pedal misapplication then the assumption is that drivers are basically flooring the accelerator pedal at start up. This whole notion of pedal misapplication was covered earlier in this discussion and is clearly seen to be of no merit. Further, there is the fact that even after the mass installation of the BTSI, the number of sudden accelerations in proportion to the number of vehicles has not changed. At the same time that the BTSI was introduced the stand alone vacuum-based cruise control was replaced by the stepper motor cruise control. For a short period of time it looked like there was some reduction in the number of sudden accelerations. With two variables changed at the same time in an equation there is no way to attribute any cause and effect to either of them. Within a short period of time following the change to the stepper motor style the number of sudden acceleration events began to reach the same proportions as prior to it and the BTSI installation.

NHTSA WAS EITHER HOODWINKED OR ASLEEP AT THE SWITCH --- PROBABLY BOTH

The Audi investigation opened the Pandora's box of electromagnetic

interference problems. The National Highway Transportation Administration (NHTSA) issued a document in 1975 that warned of the growing potential of EMI in the modern vehicle as it evolved electronically and electrically. NHTSA has chosen to ignore this document in its desire to perpetuate the myth of driver error. The Audi investigation was conducted by the same testing group that was hired in 1988 to do a study of the growing problem of sudden acceleration. Along with this testing group there were several other members from various scientific backgrounds. All but one person associated with this investigation, including the head of NHTSA at that time, had existing ties to and/or went on to work for the auto industry in one aspect or another. This was hardly an objective testing group. This study has been the main defense of the auto industry against sudden acceleration claims. At times it has worked, however, when there were witnesses to the fact that the driver was not on the accelerator pedal the defense didn't work.

The result of this new round of cover up was published in 1989. It tested 10 vehicles representing the 10 models that had the highest sudden acceleration complaint rate. The basic result of the study was that these particular ten cars didn't have an event while they had them, therefore all sudden acceleration events around the world could be attributed to driver error. They did very little EMI testing. What they did do was bench testing on some left over Audi cruise control modules. The actual result of the bench testing was that it was impossible to collect any usable data since the generated EMI for testing disrupted the recording instruments. However, these objective

testers had no qualms about making the statement that they had exhaustively tested and found no proof that EMI caused sudden acceleration and that it must therefore be the driver. These testers also lumped into their diagnosis that a brake malfunction must also occur, having bought into the brakes always win story. An interesting aspect of this study is buried in an appendix that was data from the original Audi investigation. There is mention of one vehicle that had a sudden acceleration while stopped at a traffic light. This is all that was done, just a mention of it, there no follow up investigation.

The study also aided the cover up by the auto industry with the following assertions.

1. That a sudden acceleration included some form of brake failure having to occur.

2. Since this study was of vacuum based cruise control units that two electrical faults would be needed to activate the vacuum and vent solenoids and a single fault would not cause it (no testing of this claim was ever made).

3. That what are normal operating parameters of the cruise control were called safety devices.

4. A complete dismissal of the aspect that such devices as dump valves that open the vacuum lines when the brake is pushed have only one reason to exist, the mitigation of sudden acceleration effects. It is interesting to note that the brake pressure switch, the equivalent of the dump valve in the all electric Ford next generation cruise control, could also start fires.

Looking at each of these cover up topics they are all readily disproved. Remember that the brake system was never meant to operate with the throttle wide open. The braking system is doing the best it can under a condition that it was never designed for. This was true at the time of this study and continues to be true to this day. The braking interaction has become more complicated with the addition of anti-lock brake systems (ABS), automatic traction control (ATC), and various forms of rollover sensing and reaction. No brake failure was necessary under a sudden acceleration event.

The vacuum based cruise control indeed had both a vacuum and vent solenoid that under normal operation required one to open and the other to close. What these investigators never even looked at was the electronic circuitry of the cruise system. Had they done so they would have found that the firing command for these solenoids was the result of a single signal command from the integrated circuit comparator. A single false signal will fire the required output to open the throttle. The concept of grounding out both the vacuum and vent solenoids wasn't a requirement for failure, it was a standard test in the service manual for solenoid operation.

The idea that such input parameters as the brake not being applied and the vehicle's speed being over 26mph are anything more than normal operating parameters is absurd. The fact that under normal operation the tapping of the brake will place the cruise into standby mode is also only a normal operating parameter not a safety device. When a false signal, an EMI event, occurs, the output side of the device

is affected and the normal input parameters have no bearing on the units operation under this condition.

CONCLUSION

It seems incredible that after all these years of sudden acceleration claims, deaths, injuries and ruined lives that the auto industry has chosen to not address the problem. They have chosen to spend millions to cover up and try to discredit the victims. They have lied to and brought NHTSA into their duplicity. The auto industry has been unable to prove that driver error is the cause of these accidents since all of the evidence points to the vehicle. There are over a hundred years of EMI knowledge and how to prevent it and yet these preventive measures are not employed in the vehicle. The fact is that no auto manufacturer has ever evaluated the EMI effects of interconnection of components, only simplistic EMI testing on the vehicle from outside and on a component in bench testing. Basically, the auto industry has done everything possible to maintain the illusion of safety while maintaining a lower bottom line.

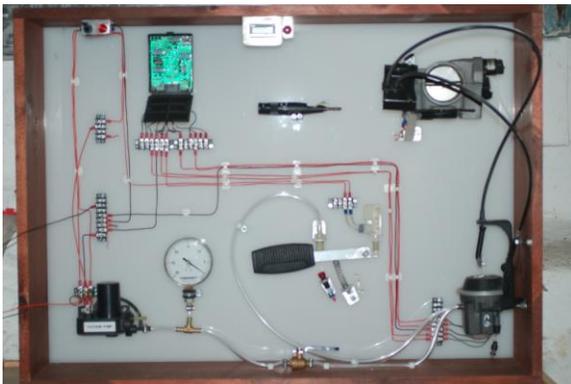
This brief paper is a synopsis of nearly twenty years of research on sudden acceleration. The research, testing and documents compiled over this period and on which this paper is based are available on my web site, www.forensicfacts.com.

Samuel J. Sero BSEE, P.E.

Mr. Sero has over 40 years of diverse engineering experience. For the past 20 years he has worked as a Forensic Engineer spending a quarter of his time in the investigation of vehicle electrical and electronic system malfunctions. Besides serving as an expert in the investigation of hundreds of accidents, he has appeared on Dateline and on UK television channel 4 discussing sudden acceleration.



Partial typical wiring harness



Vacuum based cruise exhibit