Increasing Public Adoption for Collision-Avoidance Technologies

Policy Analysis

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Every year on America’s roadways more than thirty thousand fatalities take place involving a motor vehicle, and an even larger number of injuries. The National Highway Traffic Safety Administration (NHTSA) states that sixty percent of those fatal crashes involved only one vehicle. Driving has become more dangerous than ever before and, as technology progresses, the distractions only increase.

NHTSA focuses their efforts on two areas: reducing injuries and fatalities related to (1) driver behavior and (2) vehicle safety. Driver behavior is the more difficult area to manipulate, but NHTSA has been very successful in promoting life-saving devices, e.g. *Click It or Ticket* (promoting the usage of seatbelts). The second area, vehicle safety, has had many strides within the past decade, including the standardization of technology known as Electronic Stability Control (ESC), which detects and then reduces the loss of traction between tires and the road. As technology improves, vehicle safety is changing. Driver behavior is no longer manipulated based on public ad campaigns, but by computer automation.

Computer automation of a driver’s habits is not an entirely new concept, but is starting to find its way in to many production automobiles. These collision-avoidance technologies are alluding to what is known as the preventative stage of an automobile accident, which is the only stage in which a driver can completely avoid a potential collision. When these technologies are installed on a vehicle their sole purpose is to continuously evaluate the environment around the vehicle, and be ready to apply whatever mechanical maneuvers are necessary to impede a collision with other cars or even pedestrians.

Collision-avoidance technologies that are currently offered, only as an option, on production vehicles that aid in the area of preventative strategy are: forward-collision warning/avoidance, lane-keeping assistance/blind spot detection, adaptive cruise control, adaptive headlights, backover protection, curve speed warning, fatigue warning, automatic park assist, and vehicle-to-vehicle (or infrastructure) communication. These technologies are on the market, but are not widely publicized for their life-saving advantages. This addresses the following question: What will it take to make these technologies known and adopted by the American consumer? Will the market persuade consumers to purchase these options, or will the government have to intervene? It is likely to be a joint venture between the market and government to ensure mass commercialization of collision-avoidance technologies.
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<tr>
<td>DOT</td>
<td>Department of Transportation</td>
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<td>IIHS</td>
<td>Insurance Institute for Highway Safety</td>
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<td>HDLI</td>
<td>Highway Data Loss Institute</td>
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<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
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<td>NCAP</td>
<td>New Car Assessment Program</td>
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<td>EURO NCAP</td>
<td>European New Car Assessment Program</td>
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<td>FMVSS</td>
<td>Federal Motor Vehicle Safety Standard</td>
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<td>ABS</td>
<td>Anti-Lock Braking System</td>
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<td>TCS</td>
<td>Traction Control System</td>
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<td>ESC</td>
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INTRODUCTION

The term “collision-avoidance” encompasses a variety of computer-controlled systems on a motor vehicle that aid a driver in safely operating a motor vehicle. Since their early introduction, collision-avoidance systems function and operate in various ways depending mainly on what the vehicle manufacturer hopes to achieve in safety. These systems help to influence safety on a driver’s behavior by taking information in from two factors: the driver’s input (acceleration, braking, and steering) and the surrounding environment. Using this continuously gathered information, these technologies can warn the driver or, in some cases, control the vehicle in the event of an impeding collision.

Collision-avoidance’s purpose is to avoid a collision at all costs, i.e. automotive preventative strategy. In 1969, Director of the National Highway Safety Bureau (NHSB), predecessor to the National Highway Traffic Safety Administration (NHTSA) today, created what is known as The Haddon Matrix. According to the Emergency Medical Services (EMS), the matrix exists as “a public health model to the "epidemic" of traffic-related injury.” The matrix outlines three stages to a crash: pre-event, event, and post event. Collision-avoidance technologies occur as a useful addition only during the pre-event stage of an incident, and potentially eliminate the other stages (or at least mitigate the effects of the other stages.)
The purpose of this thesis is to provide information on current collision-avoidance technologies on the market, and to provide successful strategies to increase public adoption of these technologies. Public adoption can be increased by two means: government intervention or market forces. This thesis comes to the conclusion that a balance of the two means will increase adoption of collision-avoidance technologies. The following technologies will be discussed in further detail: forward-collision warning/avoidance, lane-keeping assistance/blind spot detection, adaptive cruise control, adaptive headlights, backover protection, curve speed warning, fatigue warning, automatic park assist, and vehicle-to-vehicle (or infrastructure) communication. It is imperative to take a step back and introduce previous technologies that have laid the groundwork for computer-controlled automotive safety, such as: Anti-Lock Braking Systems, Traction Control Systems, and Electronic Stability Control.

PART I: Previous Collision-Avoidance Technologies

Collision-avoidance technologies are not necessarily new in the arena of automotive safety. Prior to today’s advanced collision-avoidance systems there were three systems that set the market for computer-aided driving: Anti-Lock Braking System, Traction Control System, and Electronic Stability Control.
ANTI-LOCK BRAKES

The first example of collision-avoidance technology is a computer-controlled system of a car’s braking system, i.e. anti-lock braking system (ABS). ABS was the first of its kind to enable an engineer to compensate for a bad driver. This system made its first debut as an option mid-year 1969, on Ford Thunderbirds and Lincoln Continental Mark IIIIs, and was given the option name Sure-Track Braking.\(^1\) ABS was designed to prevent a vehicle from skidding during a period of maximum braking, and did not allow for the wheels to lockup that allowed the tires to continue making contact with the roadway surface. The braking force of a vehicle is immensely improved when a tire has good traction versus a tire that is only skidding across the surface. This system led to one of the very first computers being integrated in a vehicle, which obtained all of his information from electronic wheel sensors.

The system had gone through many rigorous tests, which amassed ten years before even coming to the market, compiling sufficient evidence to make it a statistically proven safety feature.

The system was introduced under different titles for different vehicle manufacturers, e.g. Track Master (Cadillac), True Track (Oldsmobile), and Sure-Brake (Chrysler Imperial).\(^2\) Most the systems continued on in future model years, except for Chrysler’s four-wheel anti-lock brake system because of its huge expense and lack of sales.

ABS was introduced strictly based upon market forces and automotive manufacturer implementation, but never government regulation.

The National Highway Traffic Safety Administration (NHTSA) states, “the real world crash avoidance performance of these systems appears to be below expectations” and thus ABS never became a Federal Motor Vehicle Safety Standard (FMVSS).\(^3\)
Since the introduction of ABS, vehicle manufacturers have been voluntarily equipping the technology to modern vehicles at a rate of 55 percent.\textsuperscript{4} It is important to note that vehicle manufacturers will voluntarily apply certain technologies they deem appropriate, and market forces will create mass public adoption.

**TRACTION CONTROL SYSTEM**

To further improve the contact of a car’s tires with the road surface a supplemental computer-controlled system was added called Traction Control System (TCS). TCS was first developed as a mechanical system, and later became computer-controlled adding to an already ABS equipped vehicle. The system is designed to deal with lateral (front-to-back) loss of friction only under acceleration.\textsuperscript{5} For example, if the roadway surface has turned to ice and becomes slick then the friction between the vehicle’s tires and the road is almost nonexistent. In this case, TCS’s computer will take over and regulate the engine speed and the power that your wheels are receiving not allowing you to spin out. One way to envision TCS is realizing it is the opposite of ABS; concerned with *acceleration* and not *deceleration* (ABS). Traction control started to gain momentum as an offered safety option, but it was not until a technology package, called Electronic Stability Control (ESC), that such a system was mandatory for new vehicles in the United States.

**ELECTRONIC STABILITY CONTROL**

ESC has become the most recent FMVSS, which mandates that an onboard computer continuously monitor and step-in when necessary in times of reduced traction.
The system works directly with ABS and TCS technologies [Because ABS and TCS technologies work directly with ESC they became grandfathered in], and in the event the wheel sensors detect that a driver might be losing control of the vehicle, the computer will take over for the driver by braking specific wheels and or reducing engine speed.

NHTSA mandated ESC once its effectiveness was proven, and by model year 2012 100 percent of vehicles were to be outfitted with this groundbreaking semi-autonomous vehicle technology.6

The ESC mandate will serve as a comparison case study when talking about new collision-avoidance technologies that are currently being reviewed. When NHTSA mandates any automotive features it is crucial that they obtain all the data they can, and past FMVSS will be used as a comparison in adding any additional technologies as “standard”. The process of mandating safety technology will be discussed in further detail upon first talking about proposed new safety technologies. It is important that new technologies be fully justified in safety, performance, and reliability. The key piece of evidence that policymakers rely on is real world performance.

The Insurance Institute for Highway Safety (IIHS) uses insurance data to accurately predict real world performance, and the following technologies are under evaluation:

- Forward-collision warning/avoidance
- Lane-keeping assistance/blind spot detection
- Adaptive cruise control
- Adaptive headlights
- Backover protection
- Curve speed warning
- Fatigue warning
- Automatic park assist
- Vehicle-to-vehicle (or infrastructure) communication.

The goal is to take these technologies and persuade consumers that they can benefit from their safety, and persuasion comes from government intervention or market force.

Part II will discuss each of these systems separately, and identify what their safety capabilities are.

PART II: PROPOSED COLLISION-AVOIDANCE TECHNOLOGIES

Collision-avoidance technologies exist in different forms of technology, usefulness, effectiveness, and stage of autonomy. It is important to note that there are different forms of vehicle autonomy. The following proposed technologies are a step towards the future of a fully autonomous vehicle. An autonomous vehicle is a vehicle that needs no human intervention when navigating the roadway, you simply put in your address and the vehicle does the rest for you.

However, the safety technologies that are being proposed in this paper are only semi-autonomous features, still requiring human intervention at all times.

In *Liability and Regulation of Autonomous Vehicle Technologies* the California PATH Program: Institute of Transportation Studies breaks vehicle autonomy down in to six distinctive levels.  

**Figure 1** illustrates the six levels of vehicle autonomy and the circled levels are the levels that the proposed collision-avoidance technologies are categorized under.
The second level of vehicle autonomy contains all systems that simply warn the driver of a potential dangerous situation by displaying text and or an audible warning, such as helping a driver maneuver a simple lane change (blind spot detection) or alerting that a car in front is braking (forward collision warning). The third level involves computer-controlled systems that can assess a situation and take matters in to its own hands if necessary, such as Adaptive Cruise Control and Forward Collision Avoidance (actually avoiding a potential collision not just alerting the driver).

FORWARD-COLLISION WARNING/AVOIDANCE

The first system proposed is called forward-collision warning/avoidance technology. These systems sometimes coexist or are separate depending upon the vehicle manufacturer and consumer options purchased. Forward-collision warning systems (FCWS) provide either an audible warning or a text warning of a potential front-end crash in either highway conditions or city conditions. However, some of these warning systems can include autonomous braking, allowing a vehicle to brake itself if the driver fails to do so in a timely manner. \(^8\)
An example of FCWS with autonomous braking is City Safety by Volvo. City Safety was designed with the intent of city traffic (including pedestrians). The system only works in low-speed scenarios. Volvo states that City Safety can fully avoid a potential collision at up to 9 MPH, and only mitigate the effects of the collision at up to 19 MPH. This system will not provide any forward collision safety under highway conditions. However, according to Volvo, 75 percent of all crashes involve speeds in the 19 MPH or less range. The system will not only detect vehicles, but also a pedestrian. According to Thomas Broberg, Senior Safety Advisor for Volvo, City Safety “is programmed to trace a pedestrian’s pattern of movement and also to calculate whether he or she is likely to step into the road in front of a car.” According to Volvo’s website, four out of their seven available models list City Safety as standard, and the other three models do not even list the safety technology as an option.

It is necessary to explain that the system has two major limitations: (1) the system can be turned off by the driver (but is set to default to on when car is restarted) and (2) in adverse weather conditions the sensor can be compromised with dirt or snow.

The Highway Loss Data Institute (HLDI), part of IIHS, evaluated FCWS’s (with autonomous braking) effectiveness based merely on insurance claims for property damage liability (PDL). [PDL covers damage caused by an insured vehicle to other vehicles, and collision insurance, which covers damage to the vehicle under the insurance policy.] According to HLDI, claim frequency was 14 percent lower on models that were equipped with FCWS with autonomous braking than without.

The European Union (EU) is taking the technology of autonomous braking one step further than the United States by issuing a mandate. The mandate requires all commercial vehicles to have the optional FCWS with autonomous braking provided as
standard equipment by November 2013.\textsuperscript{14} The reason for issuing a mandate of the technology on commercial vehicles first is to provide real world data proving the effectiveness of FCWS. However, to incentivize private vehicle manufacturers the European Union New Car Assessment Program (EURO NCAP), starting in 2014, will evaluate the effectiveness of autonomous braking, and in order for a vehicle manufacturer to achieve a 5-star safety rating they must include autonomous braking.\textsuperscript{15} The EU is hoping that this added “safety incentive” would increase public adoption of autonomous emergency braking.

LANE-KEEPING ASSISTANCE/BLIND SPOT DETECTION

The next recommended safety option includes lane-keeping assistance and blind spot detection. These systems are normally added together as one safety option on newer model cars, so they will be discussed together. There are two types of lane-keeping features: lane departure warning (LDW) and lane-keeping assistance (LKA). LDW uses a camera located in the rearview mirror to constantly monitor the vehicle in between driving lanes.\textsuperscript{16} If the vehicle should stray across these vehicle lanes then the driver will be notified via an audible tone, shaking in the steering wheel, or the seatbelt will tighten. However, on the other hand LKA will also notify the driver during the same scenario, but will take corrective action in the steering to keep the driver in his/her lane.\textsuperscript{17}

The EU has done extensive studies on the effectiveness of lane departure warnings and or lane-keeping assistance. According to an EU study on lane-keeping, all visual lane-keeping warnings are ineffective because of a potential inattentive driver, but auditory warnings prove more successful in getting a driver’s attention.\textsuperscript{18} IIHS
disagrees with audible warning as a proven success, because drivers tend to get frustrated with numerous audible tones and thus disable the system for the rest of their drive. However, IIHS has found that insurance claims are being reduced on vehicles equipped with the technology, and it is estimated that the warning system alone could prevent or mitigate up to 7,529 fatal crashes. Unfortunately LKA technology is relatively new and is not equipped on enough vehicles in the United States to conduct an insurance claim evaluation, so its real-world success is unknown to IIHS researchers at this time.

Blind spot detection (BSD) is the other system linked with LDW and LKA. With BSD installed on a vehicle, the vehicle has the knowledge of any vehicles that are located in the lane next to the vehicle. The sensors can detect a vehicle and alert the driver via an audible tone and most notably a light on the side view mirror. According to the IIHS, around 450,000 crashes occur per year, and around 428 of these blind spot crashes result in driver fatality. The effectiveness of the system is proven to be useful, but the driver compromises this when they fail to even look in side view mirrors.

ADAPTIVE CRUISE CONTROL

Adaptive cruise control (ACC) functions with sensors on the front bumper of a vehicle, and these sensors are consistently measuring the distance between your vehicle and the one in front of you when cruise control is set. When the sensors sense an object in front of it going at a slower speed, then it will brake the vehicle to maintain a safe distance until the object in front has moved and then the preselected speed will resume. The system has a strong advantage in adverse weather conditions because it cannot be compromised in fog or rain.
The overall effectiveness of this system is not entirely realized yet, because of insufficient real-world data. ACC is an expensive option at more than $1,500 on most new cars. This pricing barrier has limited widespread introduction to all vehicle models as even an option, but upon standardization and lowering costs of technology it is likely the option will be found on lesser expensive vehicle models.\textsuperscript{22} Today, you will find ACC systems combined in an automotive safety package, not necessarily a stand-alone option.

**ADAPTIVE HEADLIGHTS**

Adaptive headlights create a connection between steering input and a car’s headlights. The headlight is able to bend with the slightest turn of a vehicle’s steering and shine light in to the bend of a curve, rather than in a straight line. IIHS has found a ten percent reduction in PDL claims, which is a surprising effect because only seven percent of police claims show crashes between 9 PM and 6 AM.\textsuperscript{23} Adaptive headlights have yet to thoroughly be researched, but they are showing astounding effectiveness in more situations than just night driving.

**BACKOVER PROTECTION**

Backover protection evolved out of a serious issue that pertains to kids being injured or even killed because a driver was backing out of a driveway and could not see what was behind them.
According to the nonprofit child safety organization, *Kids and Cars*, at least 48 children seek medical help relating to injuries from backovers, and at least two children are killed every week. The system that is being equipped on some vehicles to help eliminate the problem is a rearview camera (visual warning) and continuous beeping noises (audible warning).

The NHTSA has proposed that vehicle manufacturers install rear visibility systems for these low-speed accidents. The proposed mandate would have required 100 percent of automakers to install these rear visibility systems in all vehicles by 2014. This mandate would provide for a transition period, only requiring a certain percentage of a vehicle manufacturer’s fleet to be equipped with the technology. However, the mandate was delayed yet again for the fourth time since its introduction in 2007 because of the rising costs that it forces on the auto industry, which NHTSA says could add costs up to $1.6 billion on automotive manufacturers.

**CURVE SPEED WARNING**

Curve speed warning (CSW) was developed to warn drivers about the potential dangers of taking an upcoming curve too fast. The system uses pre-existing map technology, wheel sensors, and rain sensors [to monitor situations in which there may be less friction between the tires and the road] to effectively judge if a driver should slow down to maneuver a curve safely. The system was designed to inform the driver with visual alerts and audible tones, but also to supplement curve warning signs on the roadway. The system is still in the testing stage, and not offered on vehicles in the United States as an option, so the effectiveness is still unknown because of a lack of real-world data.
FATIGUE WARNING

Fatigue warning systems are a relatively new option, which is currently being studied and not available on new cars, which monitor a driver’s impairment due to drowsiness. These systems monitor driver drowsiness in a variety of ways: steering wheel movement, lane changes, eye movement, and even facial feature movement to most accurately depict if a driver should pull over and rest. Our knowledge of driver vigilance systems has increased by EU studies; such as the EU project AWAKE.

The EU AWAKE project has proposed requirements that systems such as fatigue warning would need to be effective, and lists the technological feasibility of such a system. The EU study has yet to show any progress in driver adaptation of fatigue systems, and most drivers during the study simply ignored the warning signals of drowsiness that the car detected. As of yet it is impossible to standardize any fatigue warning systems in vehicles because of inconclusive research on brief sleeping episodes. These brief sleeping episodes are known as microsleep, and are short unintended losses of attention, which results in prolonged eye closure while trying to preform a monotonous task such as driving a vehicle. Until more research is completed on the study of microsleep, fatigue warning systems will not be completely successful.

AUTOMATIC PARK ASSISTANCE

Automatic park assistance (APA) is the closest technology we have towards self-driving cars. APA is designed to eliminate the practice of parallel parking by human interaction, and gives the onboard computer full control of the steering, acceleration,
and brake. According to Ford Motor Company’s Active Park Assist option, the driver simply pulls up to a parallel parking spot and then selects if he wants the vehicle to takeover the parking. Once the driver selects for computer takeover, the vehicle then maneuvers itself with the use of cameras and ultra-sonic sensors. Ford has claimed that the system is more of a convenience option, but has environmental impacts by reducing fuel consumption by five percent. APA leaves the automotive industry one step further towards the future of self-driving cars.

VEHICLE-TO-VEHICLE (OR INFRASTRUCTURE) COMMUNICATION

The final proposed technology, vehicle-to-vehicle (or infrastructure) communication (V2V/V2I) includes all of the above technologies’ functions wrapped in to one package. V2V/V2I is a wireless communication system that exchanges data between vehicles and even infrastructure (equipped with the technology) to alert a vehicle of the presence of surrounding objects, which can safely aid in a driver’s reactions/behaviors. According to the U.S. Department of Transportation (USDOT) V2V/V2I presents safety benefits by exchanging,

“anonymous, vehicle-based data regarding position, speed, and location (at a minimum), V2V communications enables a vehicle to: sense threats and hazards with a 360 degree awareness of the position of other vehicles and the threat or hazard they present; calculate risk; issue driver advisories or warnings; or take pre-emptive actions to avoid and mitigate crashes.”

The system provides other vehicles and buildings with a simple message that provides a vehicle’s geographical location and speed, known as the “Here I am” message. The “Here I am” message allows other vehicles and or buildings in a given area to know exactly where other oncoming vehicles are, and provides the language to allow vehicles to “talk” to one another. V2V/V2I takes on a very cooperative approach to driving,
which can potentially lead to fewer vehicle collisions [estimated to prevent up to 76 percent of collisions] and free up congestion on the roadways by allowing vehicles to travel closer together at higher speeds.\(^\text{32}\)

V2V/V2I technology is still in its infancy and many questions have yet to be answered, but most recently the USDOT and the University of Michigan Transportation Research Institute (UMTRI) have teamed up to conduct the first safety pilot test of this technology. The safety pilot test will provide for real-world usage of this technology by implementing a one yearlong test in Ann Arbor, MI with approximately 2,850 V2V equipped vehicles.\(^\text{33}\) The USDOT and the UMTRI have mapped out the approximate locations (on Ann Arbor, MI roadways) where they want these vehicles to connect and communicate using wireless data, which means vehicles would have to “talk” with buildings, stoplights, and other vehicles on the road that are wirelessly equipped.

The USDOT hopes to gather enough information in this pilot study to promote V2V/V2I’s effectiveness and possibly push automotive manufacturer’s to do independent research on the technology. As with most technologies in their early infancy, connected vehicle technology is too new and unknown to propose a mandate yet, but upon success of the safety pilot test it is likely further testing will occur by automotive manufacturers.

**PART III: MARKET IMPERFECTIONS**

The collision-avoidance technologies that I proposed in Part II still contain great challenges that must be addressed. A question every consumer might ask is: why don’t automakers voluntarily offer these technologies on their own, instead of being pushed by a market or government force? Simply put, every market has barriers of entry or
what are known as market imperfections. I have devised a list of four imperfections that make automakers think twice before simply voluntarily adding any of these technologies to a vehicle such as (1) a driver’s perception of risk, (2) benefiting parties, (3) no-fault auto insurance, and (4) first adopters bear market and legal risks.

1. A Driver’s Perception of Risk

The words automobile and risk are inseparable from one another, and every day motorists bear the uncertainty of knowing the future outcome of any action they take while operating a motor vehicle. The demand for collision-avoidance technologies can and will only be realized if/when motorists perceive the task of driving as more of a danger and threat to an untimely demise. For example, Japan is dealing with the dilemma of increasing traffic accidents, but not necessarily traffic fatalities. To analyze this increasing occurrence Japanese researchers are analyzing driver behaviors through computer simulations.

According to the research study, Assessment of a Driver’s Risk Perception Using a Simulator by Toyota Central Research and Development Labs, Inc., drivers’ judgment errors, also called “prejudices”, are what cause traffic accidents. A “prejudice” alludes to a driver’s cognitive status being overconfident in what is perceived as risk, which leads motorists to think accidental risk is much lower than objective risk. Unfortunately, most research studies infer that the problem lies in a driver’s overconfidence, but as of yet researchers only know how to evaluate these “prejudices” and not correct.

2. Benefiting Parties
When acknowledging the benefits associated with any collision-avoidance technology, it is important to note that the benefits exceed past the consumer, but extend to the other potential victim in a car accident. Unfortunately, consumers don’t think of these technologies as benefits to all other motorists or pedestrians but solely as a convenience option. In order to emphasize this market imperfection it is important that it be depicted in a more relatable manner.

For example, a consumer has the option to purchase his new automobile with adaptive cruise control (ACC). For the particular vehicle he is purchasing this ACC is a pricey option at an extra cost of nearly $2,000. The consumer sees this option solely as convenience and instills only a small safety benefit to him, because under highway conditions it will automatically brake or accelerate where possible/needed. However, our consumer is overlooking a very important safety benefit to the victim of a crash that could have occurred had he not purchased ACC.

3. No-Fault Auto Insurance

Under a no-fault auto insurance policy, in the case of an accident, victims seek compensation for damage done from their own insurer, rather than seeking compensation from the insurance company of the individual who caused the accident. In other words, states that allow these insurance policies never utilize tort law in a motor vehicle accident.

The fact that this type of insurance policy merely exists (currently in 12 states and Puerto Rico) means trouble for emerging collision-avoidance technologies. Policyholders with no-fault auto insurance see no practical need to purchase collision-avoidance technologies because if they are in an accident (even if they caused it) their insurance company will pay for any damage caused.
The original idea behind no-fault auto insurance was a less-expensive resolution of automotive accidents. According to the RAND Corporation in The U.S. Experience with No-Fault Automobile Insurance: A Retrospective, their studies showed no-fault auto insurance to actually be a more expensive alternative to a tort system because of extraordinarily increasing healthcare costs. However, no matter how may drawbacks exist with no-fault auto insurance it is a state-by-state discretion; only at the will of a state's political climate.

4. First Adopters Bear Legal and Market Risks

The fourth, and final reason in market imperfections entails the risks that the automotive market bear by adding these technologies voluntarily. Normally in any industry it can prove to be very beneficial to have what is called the “first mover advantage”, which means you were the first company to unveil revolutionizing feature/product in to the marketplace.

On the other hand, the first mover advantage can prove to be a very messy situation in the realm of automotive safety, especially for legality.

The United States has one of the most well regulated automotive safety arenas in the world. For automakers to add new technology voluntarily would require a large amount of litigation for areas that are not so specific or applicable.

The Center for Automotive Research (CAR) indicates in their report titled Vehicle Technology Trends in Electronics for the North American Market; Opportunities for the Taiwanese Automotive Industry, that government regulation is expected to be the automotive market’s main determinant in implementing safety technology because automakers are hesitant to introduce collision-avoidance technologies to such a litigious
customer base. Hesitation to adopt these technologies by automakers is out of fear of them failing in action, and if/when they do there are numerous players that could potentially be held liable. However, when looking at the market risks involved for an automaker it all comes down to option price and consumer acceptance of a technology.

Every year, J.D. Power and Associates conduct a *U.S. Automotive Emerging Technologies Study*, which results in a survey of consumers on interest and actual purchase intent of emerging automotive technologies. It is quite clear that the American consumer expects additional safety equipment, but they have no intention of purchasing these items; as they should be standard. The results of the 2012 J.D. Power and Associates study are located in Figure 2 (next page), which contains an initial survey for interest (not disclosing the market price of the options) and then resurveying for intent to buy (which will disclose the market price). J.D. Power and Associates also conducted a social media survey, which yielded the following responses of autonomous car technology implementation:

- Drivers believe autonomous technologies are an emerging trend, but are far off in terms of adoption because of legality and real-life implementation.
- Drivers want the option to engage autonomous functions during times of so-called “boring” driving, such as parking and highway driving, but want to regain control during pleasure driving.
- Given upfront costs of technologies and constant updates, drivers can envision vehicle-sharing programs instead of private purchases.
SPOTLIGHT | Autonomous Driving

Based on findings from the J.D. Power and Associates 2012 U.S. Automotive Emerging Technologies Study®

Autonomous driving functions, including steering and acceleration, are functions automatically controlled by a vehicle that require minimal human interaction in order to improve driving convenience or when there is an emergency.

The 2012 U.S. Automotive Emerging Technologies Study measures vehicle owners' interest in three emerging semi-autonomous driving technologies, as well as interest in a fully autonomous driving technology that is still under development.

**Fully Autonomous Driving**
Definitely/Probably Would Purchase, based on a market price of $3,000

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>Male</th>
<th>Female</th>
<th>Vehicle Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25</td>
<td>25%</td>
<td>14%</td>
<td>Premium</td>
</tr>
<tr>
<td>26-37</td>
<td>37%</td>
<td>29%</td>
<td></td>
</tr>
<tr>
<td>38-56</td>
<td>14%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>57-65</td>
<td>9%</td>
<td>9%</td>
<td>Non-Premium</td>
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</tbody>
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**Speed Limit Assist**
Definitely/Probably Would Purchase, based on a market price of $800
(Semi-autonomous—vehicle camera sees speed limit signs and adjusts speed)

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>Male</th>
<th>Female</th>
<th>Vehicle Type</th>
</tr>
</thead>
<tbody>
<tr>
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<td>15%</td>
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<tr>
<td>26-37</td>
<td>29%</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>38-56</td>
<td>14%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>57-65</td>
<td>9%</td>
<td>9%</td>
<td>Non-Premium</td>
</tr>
</tbody>
</table>

**Emergency Stop Assist**
Definitely/Probably Would Purchase, based on a market price of $800
(Semi-autonomous—engages only in emergencies)

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>Male</th>
<th>Female</th>
<th>Vehicle Type</th>
</tr>
</thead>
<tbody>
<tr>
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<td>28%</td>
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<td>Premium</td>
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<tr>
<td>26-37</td>
<td>45%</td>
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</tr>
<tr>
<td>38-56</td>
<td>19%</td>
<td>19%</td>
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<tr>
<td>57-65</td>
<td>18%</td>
<td>18%</td>
<td>Non-Premium</td>
</tr>
</tbody>
</table>

**Traffic Jam Assist**
Definitely/Probably Would Purchase, based on a market price of $800
(Semi-autonomous—steers, maintains proper distance between vehicles, and stops)

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>Male</th>
<th>Female</th>
<th>Vehicle Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25</td>
<td>25%</td>
<td>17%</td>
<td>Premium</td>
</tr>
<tr>
<td>26-37</td>
<td>31%</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>38-56</td>
<td>16%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>57-65</td>
<td>8%</td>
<td>8%</td>
<td>Non-Premium</td>
</tr>
</tbody>
</table>

Source: J.D. Power and Associates 2012 U.S. Automotive Emerging Technologies Study®

Charts and graphics extracted from this press release must be accompanied by a statement identifying J.D. Power and Associates as the publisher and the J.D. Power and Associates 2012 U.S. Automotive Emerging Technologies Study® as the source. Rankings are based on numerical scores and not necessarily on statistical significance.

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Figure 2. 2012 U.S. Automotive Emerging Technologies Study
Source: http://autos.jdpower.com/content/press-release/gG0wCnW/2012-u-s-automotive-emerging-technologies-study.htm

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Given these factors of legal liability, consumer acceptance, and lack of real-world usage of these technologies, automakers are reluctant to take the first mover advantage. It is more likely that most manufacturers will wait and see the technology play out, and implement the technology by copying the first mover.

PART IV: RECOMMENDATIONS FOR ADOPTION

Increasing public adoption of automotive collision-avoidance requires intervention of both government and market forces. I recommend three different options that will promote and increase adoption of the previously discussed technologies: (1) Government Action: Issuing a Federal Motor Vehicle Safety Standard (FMVSS) of a proposed technology, (2) Market Action: Insurance premium reductions for policyholders who adopt collision-avoidance technologies, and (3) Government/Market Action: New Car Assessment Program (NCAP) includes these technologies to achieve 5-star safety rating. Upon implementing any of these three options, the public will see these options standardized (consumer vehicles must be equipped with the technologies) or make them more apparent (market advertising of safety will persuade consumer purchases).

1. GOVERNMENT ACTION: FMVSS

The NHTSA is legally obligated to write vehicle safety mandates that manufacturer’s must meet and comply with in order to sell a vehicle in the United States. The legal power for these mandates comes under Title 49 of the United States Code in Chapter 301, called Motor Vehicle Safety.
FMVSS 209, seatbelts, was the first mandate of vehicles in the United States, which required all vehicles manufactured on and after January 1, 1968. Since 1968 all regulations written for the automotive safety industry only require manufacturers to meet minimum safety performance criteria. The minimum safety performance criterion comes from a review of all current safety options on the market, and makes sure “that the public is protected against unreasonable risk of crashes occurring as a result of the design, construction, or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur.”

According to Title 5 of the U.S. Code all regulations must follow a specific path before a regulatory agency can regulate or mandate on an industry – what is known as rulemaking. Under the Administrative Procedure Act (APA) all regulations must contain the following steps:

1. **Legislation** – Congress must authorize an agency with regulatory power.

2. **Advance Notice of Proposed Rulemaking** – A point of time when the public is asked of their opinion on the rule, and given any new relevant data.

3. **Proposed Rule** – Regulatory language is posted in the Federal Register, along with any useful public comments from Step 2.

4. **Public Comment** – A period of time of 30 to 180 days (depending upon severity of the issue) where the public is allowed to comment and the agency must respond to any issues raised.

5. **Final Rule** – After the public comment period is closed a modified rule is added to the Federal Register once again, and if no additions are made or corrected the rule gets codified in the Code of Federal Regulations.
6. **Judicial Review** – If someone files a lawsuit against the rule being improper, then the courts will review it to see if the regulatory agency has the power to issue the regulation.

7. **Effective Date** – The final step is the date at which the rule becomes a law, and usually allows time for the industry to comply with the new regulation (phase-in period – certain percentage of a vehicle manufacturer’s fleet must be equipped by a certain date).

The regulatory process is one of the most time consuming processes and can take several years to even prepare for, because of all the data and information that must be obtained before hand. The NHTSA is a regulatory agency and has the authority to administer a regulation on the automotive industry, but they also can administer non-legislative rules. Non-legislative rules are very similar to regulations, only they are non-binding, which means they simply provide “guidance” to the automotive industry.  

This “guidance” seeks to influence manufacturers to provide particular features even though they are not mandated, sometimes incentives will be provided.

As with any rule it is crucial to know how much will be saved (monetarily), or from a health perspective how many lives will be saved. So, a cost-benefit analysis is done for each proposed regulation. Assuming the benefits outweigh the cost, it is likely a regulation will be imposed. For instance, when working with automotive safety, the DOT uses a figure known as the Value of Statistical Life (VSL). The VSL places a monetary value on a human being’s life, which according to the DOT was $9.1 million in 2011, and is adjusted with time.
The regulatory process can guarantee that a collision avoidance feature is added as standard and not optional (increasing public adoption of a safety option to 100% on new vehicles); however, the process can take an enormous amount of time and research.

2. MARKET ACTION: INSURANCE PREMIUM REDUCTION

The second recommendation is an incentive tactic to influence consumers in to purchasing collision-avoidance technologies, which results in lowering premiums by reductions. The proposed technologies can lower auto insurance premiums and incentivize policyholders. Utilizing this approach means simply lowering insurance premiums for those vehicles equipped with collision-avoidance technologies, but first it is important to explain how auto insurance companies arrive at a policy premium for a driver.

Auto insurance premiums are affected by a number of characteristics such as: age, gender, geographic location, automobile (value and year), driving history, and safety options. The second recommendation I am making is a reduction in premiums for policyholders who purchase these new innovative safety options. All automotive insurers have taken safety equipment in to account when quoting a premium, but the percent reduction can vary from company to company, and also what coverage it reduces. For example, the auto insurer GEICO offers the following reductions on certain safety equipment:

1. **Anti-Lock Brake System** – Receive a 5 percent reduction on collision coverage.
2. **Anti-Theft System** – Receive up to a 25 percent reduction on comprehensive coverage.
3. **Daytime Running Lights (DRL)** – Receive a 3 percent reduction
The issue that might hinder reductions for collision-avoidance technology is the state-by-state laws.

Automotive insurers justify giving reductions in auto insurance premiums depending on the state you live in. For example, taking a look at Farmer’s Insurance Group, they offer premium reductions for Electronic Stability Control (ESC) in states such as California and Maryland but not Indiana. The reason for different reductions in different states has to do with the state’s law. In order to provide a market push for collision-avoidance technologies it would be most beneficial to have these reductions available to everyone, requiring a change in the law (subject to 50 regulatory bodies.)

Currently no insurance companies in the United States offer premium reductions for the technologies I proposed. However, in the Europe these reductions do exist.

Europe has always been one step further than the United States when it comes to automotive safety. Volvo has been working with insurance companies in Europe to add reductions for safety equipment, such as their autonomous emergency braking function City Safety. According to Volvo, around Europe and elsewhere in the world they are starting to see a 10-30 percent reduction in auto insurance premiums. Companies such as Volvo and Mercedes have been lobbying in the United States since passage of European reductions, but unfortunately no success just yet. Auto insurers state that until more of the U.S. vehicle fleet is outfitted with such technology there is no use. However, not allowing reductions for collision-avoidance technology sends a negative message to American consumers, which says that the technology is not useful or effective.
3. GOVERNMENT/MARKET ACTION: NEW CAR ASSESSMENT PROGRAM (NCAP)

The third recommendation involves government interaction, which in turn will increase public awareness. Safety information for automobiles in the United States comes from one government source, the New Car Assessment Program (NCAP) operated by the NHTSA. The NCAP was started in 1979, to better improve occupant safety by developing and publishing meaningful safety information on new automobiles for consumers, and incentivizes automobile manufacturers to voluntarily improve vehicle safety.

Since its introduction, NHTSA has revamped the consumer delivery system to increase accessibility and a user-friendly format in terms of a website, www.safercar.gov, and an easy to interpret rating system.

VEHICLE SAFETY RATINGS

First, let’s take a look at the rating system used to inform a potential car shopper. Each vehicle is given a number on a scale from 1-5, which rates the safety performance of an individual make and model [1 – poor safety performance and 5 – excellent safety performance]. The rating is based upon a vehicle’s safety in frontal and side impacts, and its performance in a rollover scenario. This performance score is then posted as part of the Monroney label (window sticker) – since 2007, seen in Figure 2 (on the following page), and on the SaferCar.gov website, which is a requirement by federal law for every newly manufactured vehicle [see Appendix for full window sticker]. The NCAP testing provides one of the most comprehensive tests for the American consumer who is an informed car shopper, but the NHTSA has suggested that the NCAP needs assistance in the following areas:47
1. Include more “realistic” crash tests to better depict the fatal crashes on American roadways.

2. Enhance how the consumer safety information is presented and its timeliness in reporting.

3. Include further tests on new technologies emerging in the current vehicle fleet (such as collision-avoidance technologies).

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**GOVERNMENT SAFETY RATINGS**

<table>
<thead>
<tr>
<th>Frontal Crash</th>
<th>Driver</th>
<th>Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>★★★★★</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>

Star ratings based on the risk of injury in a frontal impact. Frontal ratings should ONLY be compared to other vehicles of similar size and weight.

<table>
<thead>
<tr>
<th>Side Crash</th>
<th>Front seat</th>
<th>Rear seat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>★★★★★</td>
<td>Not Rated</td>
</tr>
</tbody>
</table>

Star ratings based on the risk of injury in a side impact. Safety concern: Visit www.safercar.gov or call 1-888-327-4236 for more details.

<table>
<thead>
<tr>
<th>Rollover</th>
</tr>
</thead>
<tbody>
<tr>
<td>★★★★★</td>
</tr>
</tbody>
</table>

Star ratings based on the risk of rollover in a single vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest.


**www.safercar.gov or 1-888-327-4236**

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*Figure 3. NCAP Safety Rating (located on Monroney Sticker)*


I would like to focus on two of those key issues, (1) enhancing safety information and (2) evaluation of current emerging safety technologies.
First, enhancing safety information for the American consumer is a necessary step towards increasing public adoption, because an ill-informed consumer is much less likely to purchase safety technologies if they do not come standard.

The NHTSA had conducted a survey that looked at what role vehicle safety information played towards the purchase of a new vehicle. The survey asked participants, who were already familiar with the star rating system, if a summarized star rating system would aid consumers better during a vehicle purchase than a separate star rating system for individual tests (like it is today).

The results swayed greatly towards a summarized version because consumers would not have to weigh tests separately to get a feeling for a vehicle’s safety performance. However, those surveyed also stressed that if the data were summarized it was necessary to include how they arrived at one conclusion. The most recent addition towards more informed consumers was just released in March of 2013, the SaferCar app for iPhone and iPod touch.

The SaferCar app provides users with a one-stop user-friendly application to obtaining vehicle safety information. The app allows a user to keep informed and up to date by completing tasks such as:

1. Viewing 5-Star Safety Ratings for vehicles
2. Locating a car seat inspection station near you
3. Search vehicle recalls
4. File a vehicle complaint
5. Most recent vehicle safety news
According to the NHTSA Administrator David Strickland, the app “literally puts the latest in vehicle safety information directly in the hands of consumers so they can make the appropriate purchasing and other decisions for themselves and their families.” Real-time information such as this app provides will not only make consumers more safety conscious and encourage consumers to think twice about a vehicle purchase.

The next step is to provide an evaluation approach for collision-avoidance technologies in the current NCAP testing.

Currently, NCAP testing only reviews safety technologies that are proven most effective (with sufficient real-world data) or is mandated by the NHTSA (such as ABS or ESC), which leaves consumers unaware of emerging safety technologies. The current problems with testing emerging technologies and informing a consumer has to do with the following three areas, which would need to be addressed prior to acknowledging technologies:

1. Insignificant market penetration; providing insufficient real-world safety data
2. Manufacturers differ immensely on design, approach, and most importantly names of technologies
3. The dynamic nature of the technologies market makes it difficult to inform consumers of technologies that are a definite safety benefit or are simply convenience options

Informing consumers about the proposed collision-avoidance technologies could mean the difference between life and death.

The NHTSA agrees that providing this information (whether providing basic technologies info or a rating system) could mean more consumers opting for technology-laden vehicles, thus increasing public awareness and ultimately adoption.
The NHTSA has come up with two approaches that I would prefer to see implemented on the Monroney sticker of all new vehicles.\textsuperscript{50} The two approaches include a vehicle grading system, an A being the highest rating and C being the lowest rating.

- **Approach #1**: In addition to the 5-Star Safety Ratings on a vehicle, each vehicle is awarded a grade based upon how many safety technology features are installed on a vehicle.
- **Approach #2**: In addition to the 5-Star Safety Ratings on a vehicle, each vehicle is awarded a grade based upon what exact safety features are installed on a vehicle. The technologies would be weighted based upon their anticipated effectiveness and anticipated target market (theoretically, how many individuals could benefit from an additional vehicle on the road with a particular safety technology.)

As of today, neither of these approaches has been available to the American consumer, and consumers are left to search elsewhere for a technologies’ effectiveness.

**MANUFACTURER INCENTIVES TO PRODUCE/PROMOTE SAFETY TECHNOLOGIES**

The second part to my third recommendation of increasing adoption of collision-avoidance technologies is a manufacturer incentive, i.e. an award system. Currently in the United States, vehicle manufacturers can receive “awards” based upon a vehicle’s safety from the IIHS. The IIHS gives out two safety awards: *Top Safety Pick +* and the *Top Safety Pick*. The awards are awarded to the top two vehicles that proved safe in all (or most) areas of testing by IIHS, which are given in 12 vehicle categories.\textsuperscript{51}
Vehicle manufacturers usually flaunt off these safety accolades in advertising campaigns, as seen in Figure 3, and provide them with a vehicle selling point, while encouraging consumers to consider safety when purchasing their next vehicle.


Figure 4. Volkswagen ad campaign touting safety from IIHS award

Unfortunately this manufacturer incentive does not exist under the NHTSA, and consumers rely strictly on information from outside of the government. My recommendation is that a vehicle manufacturer safety award system be included under the NHTSA’s NCAP. This safety award system already exists under the EURO NCAP (European New Car Assessment Program). Starting in 2010, EURO NCAP has been awarding and recognizing vehicle manufacturers’ safety technologies.
According to the EURO NCAP this reward-based system, “provides an incentive to manufacturers to accelerate the standard fitment of important safety equipment across their model ranges and helps the car buyer to make the right purchase decision.”

The system was designed to help encourage vehicle manufacturers to go above and beyond the legal safety requirements. The EURO NCAP operates in the following steps:

- **Step #1**: The vehicle manufacturer nominates their safety technology.
- **Step #2**: EURO NCAP provides a panel of judges to review safety evidence provided by the vehicle manufacturer and or real-world data.
- **Step #3**: If a technology’s performance and effectiveness can be deemed a benefit to roadway safety, then EURO NCAP will reward the technology by promoting it and any findings on their website.

Should the NHTSA design and operate a reward-based system such as the EURO NCAP’s *Advanced Rewards*, and then awareness for the proposed collision-avoidance systems could dramatically increase. In turn, a dramatic increase in consumer awareness will create an increase in public adoption.

**CONCLUSION**

Increasing public adoption for collision-avoidance technologies is a task that has many beneficiaries. The more vehicles outfitted with these technologies means the more lives we can potentially save, but manufacturers and American consumers must embrace these technologies. However, in order to embrace we must be aware of what technologies exist today.
The American consumer is given a wide array of options to purchase in our free market society, but it takes encouragement from automotive manufacturers, insurance companies, non-profit organizations, and government agencies to direct consumers in purchasing safer vehicles. The recommendations that I have made will affect not only changes in government operations but also changes to the automotive and insurance market.

As drivers rely more and more on automation, it is necessary that we keep Americans knowledgeable on emerging technologies. Keeping consumers informed will be the number one issue, whether the NHTSA standardizes a safety option, insurance companies reduce premiums for technology-laden vehicles, or manufacturers are praised for their technological advances. Awareness is key, and it is important that drivers today know how to operate vehicles of the future. Thus, the solution to increasing public adoption comes from market and government interference. The safety options exist today, but as of now only you can choose how safe the automobile you drive really is.
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51 Insurance Institute for Highway Safety, *Rating System*,
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"Economic Values Used in Analyses | Department of Transportation."  


"Improving the Safety and Environmental Performance of Vehicles."


<http://www.safercar.gov/Resources>.


"Volvo City Safety | Euro NCAP - For safer cars crash test safety rating."
