Delphi Design Project

Emergency Vehicle Intersection Sensor Technology

E.V.I.S.T

DELPHI

Innovation for the Real World

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Introduction and Problem Statement:

All emergency vehicles are equipped with appropriate lights and sirens to alert other vehicles of their presence. Even with these precautions set forth, not all drivers are aware of incoming emergency vehicles because of distractions like cell phones, passengers, loud music, etc. Busy intersections are where these numerous accidents occur. In fact, the Pennsylvania Department of Health for 2007 stated that 190 motor vehicle accidents involving ambulances were reported. 87 (46%) of these accidents occurred at intersections. Data found in other states also supports that accidents at intersections is a national problem, even when lights and sirens are running (1). This is not only an issue with ambulances, but also other dispatch vehicles like police cars and fire trucks. The US Department of Transportation states that in 2012, 16 fatalities occurred from ambulances, 9 fatalities from fire trucks, and 35 from police vehicles in emergency use (2). Many lives and money taken from accidents can be saved if a new form of communication between dispatched vehicles and motorists is put forth.

Executive Summary:

The design team worked to create an effective sensor system, which allows emergency vehicles to safely pass through intersections without accidents occurring with other vehicles. Global Position Systems (GPS) combined with Collision Warning Systems are utilized to notify and potentially stop drivers when incoming emergency vehicles are at intersections. Since the team is using a combination of previously added vehicle accessories, only new programming needs to be installed for communication between vehicles to occur. Because our design uses technology already built into the vehicle, very minimal costs are needed to create the product.

Research and Calculations:

Of all reported accidents in the United States, approximately 40% each year occur at intersections (3). This is a major issue as these very small sections of roads are becoming more and more dangerous. The first issue is when a township or state should decide that a particular intersection is too dangerous. The second is how it should be dealt with. The current solution is to just close the intersection from one direction so that there is no cross traffic, but this then creates many logistical issues as new routes are needed to get through those areas. Of the massive number of intersection accidents, almost all of them are related directly to driver fault (3). This shows that while many accidents occur because of weather or vehicle failure, accidents at intersections are primarily the fault of humans making these areas significantly more dangerous than any other stretch of road as a deadly accident could occur at any time regardless of outside factors. Implementing this would be relatively simple as most costs would fall under non-recurring engineering costs. The US Department of Labor places the average hourly wage of a computer programmer (who will do almost all the work developing E.V.I.S.T.) to be $38.91 (7). With most cars coming standard with the required systems, a small number of people would have to pay to have these added on. With one-time costs leading the way, and most cars only needing software updates, total costs add up to be very low compared to other designs and the timeline is very short. This allows for significant progress to be made quickly, thus leading to both increased profits and increased safety being seen in the very near future.

Customer Needs:

Various customer statements were put forth in class and discussed to find the customer needs in the market. The customer needs were then applied in our concept

generation to so that our designs met the highest amount of the stated needs. Table 1 has several customer statements and is paired with costumer needs that our group implemented in the design generation.

Table 1	
Costumer Statement	Costumer Need
Each design team should choose one (or a combination) of Delphi's three target areas—Safe, Green, Connected—as described below.	Design must incorporate or address one of the Megatrends.
Safe: Our ultimate goal is to help make zero fatalities, zero injuries, and zero accidents a reality	If focusing on Safe, design would drive accidents to zero
Protecting the driver and passenger is of upmost importance.	The design should protect the driver and passengers even better than current designs.
Airbags are an example of a reactive safety feature after a crash occurs.	*case example*
Safety features now being designed into cars are more proactive to avoid the crash all together.	The design should enable the car to avoid accidents.
Sensors are used to detect dangerous situations, and can alert the driver or even take over control of the car to avoid the situation	The design may incorporate driver alters or take over control of the acr to avoid unsafe conditions.
The use of smart phones while driving is also a major safety concern.	The design must decrease the risk of danger through cell phone use.
Green: We're passionate about creating a world with zero emissions	If focusing on Green: the design should help drive emissions to zero.
Protecting the environment is also very important to the vehicles of the future.	The design can not increase the ecofootprint of the vehicle or its use.
Hybrid and electric vehicles are becoming more popular as an alternative to traditional cars.	The design may incorporate hybrid or electric vehicle technology.
There are also other alternative fuels being explored.	The design can allow for alternative fuel considerations.
However, by simply reducing the weight of avehicle or having products that make engines run smarter or more efficient can dramatically improve fuel economy.	The design should improve fuel economy by decreasing weight, or increasing fuel efficiency, or…

***Connected*:** We have the technology to allow seamless connectivity in the vehicle—it's what consumers want, and we can make it a reality.	If focusing on Connected: The design should enable the user / vehicle to be more "connected".
The vehicle of the future should be optimally connected to maximize the driver's and passengers' experience while minimizing the driver's distraction.	The connected design should maximize the driving / riding experience while minimizing distractions.
Connecting the vehicle itself and all its sensors to the outside world should not be overlooked.	All systems inputs and outputs must be considered.
The vehicle of the future will have 100s of sensors collecting data which may be very beneficial to others.	The data collected from sensors is easlity interpreteted and available for anaylsis to meet the Connected (and Safe and Green) goals.

Concept Generation:

Three project ideas were put forth from our design team through research on the Internet and other available resources. They were: temperature based sensors in cars, stoplight sensors at intersections, and emergency extinguishers within the engines. Individual surveys were created and sent to various audiences to gather feedback on the three ideas to narrow down our concept to one single idea. Brief summaries of the designs are given below with survey analysis.

Temperature based sensor inside the car for the protection of children and pets. If children and pets were left in the car by accident, the car windows will open to lower the temperature as certain level of temperature is detected. Alarm system will be connected will with the sensors to sends out signals to notify nearby people that pets and children are in danger. The team planned to use the technology of hypersonic sound invented by Woody Norris for the alarm system for the purpose of reducing amount of noise of the product. *Survey analysis:* a large portion of people did not think the product is necessary because they believe they will not leave their children and pets alone in the car. No one wanted to pay for the technology that they felt was unnecessary and possibly quite risky if a failure occurred

Sensors on stop light to slow down over speeding vehicle. Since accidents usually occur at intersections, the group came up with the concept that forces drivers to slow down near intersections. Stop lights sends out signals that correspond to the car's braking system. Specific wave frequency will be developed for the concept. *Survey analysis:* people tended to disagree with this concept because saying that it is incomplete and unnecessary at some point. Many responses stated that this concept might cause more accidents and other serious negative incidents on drivers. For example, one of the response states: "People will disable them and other people will assume they do not have to pay as much attention since the system should save them. Additionally, speeds at or below the speed limit are more than deadly for a T-bone, unless the sensors can completely stop a car from running a red they are next to useless."

Emergency fire extinguishers within fuel tanks. The concept of this idea was to implement a chemical fire extinguisher in the fuel tank to prevent explosion and fire caused by the fuel. The technology and material for the fire extinguisher are very hard to find, there shows no results that can be used in the research process. *Survey analysis:* we had a difficult time compiling data for this design idea. Some survey takers found the idea confusing and unrefined. The uses of the product had a small window that made the desirability of the product quite low. Most people felt that the cost of the product outweighed the possible benefits leading to an uninterested buying audience.

The surveys revealed that the most appealing, even though none seemed very appealing, was the technology of sensors in traffic lights. Our group decided to refine the design to give the consumers a better idea of what the actual technology is and the uses of it. All questions asked on this particular survey can be found on the following link: https://www.surveymonkey.com/results/SM-KJL856LV/

Concept Selection:

An AHP matrix was developed to help ranked all features/requirements of the design. Table 2 can be seen below including the definitions of the features.

Table 2: AHP Matrix for Design Requirements

	Safe	Fail-Safe	Connected	Builds off old tech.	Maintainable	Cost-effective	Total	Weight
Safe	1	1	1	3	3	3	12	.25
Fail-Safe	1	1	.5	2	2	3	9.5	.20
Connected	1	2	1	3	2.5	2	11.5	.24
Builds off old tech.	.33	.5	.33	1	.5	.33	2.99	.06
Maintainable	.33	.5	.4	2	1	1	5.23	.11
Cost-effective	.33	.33	.5	3	1	1	6.16	.13
							47.38	

Safe: does the product increase the safety of motor vehiclists?

Fail-Safe: does the product have a fail-safe that can be easily used quickly and effectively?

Connected: does the product increase the connectivity of vehicles on the road not only internally but with other vehicles?

Builds off old tech.: can the product be created with existing technology?

Maintainable: is the product easy to maintain without large quantities of money/work?

Cost-effective: is the products cost effectively lower than its benefits?

From the AHP Matrix we found that Safe and Connected were the most important features that needed to be implemented into our design. Our team had three major designs

put forth, which were referred to as Emergency use, Commercial use, or Hybrid use of sensors in traffic lights. The major design ideas came from our winning design of traffic sensors that was a more general, undefined design at the time of surveying. Emergency use meant that the sensors in the traffic lights would only activate when dispatch vehicles were passing through intersections. Commercial use meant that sensors in traffic lights would be active 24/7 and would regulate the speed of commuting vehicles. The hybrid idea was a combination of the commercial and emergency use, where the commercial would be active 24/7 and emergency vehicles could manipulate that when needed.

Once the weight of each requirement was found, it could then be used to determine which of our three design concepts should be used. A Design Selection matrix was created to compare each design with weighted/unweighted values that are shown in Table 3.

Table 3: Design Selection Matrix

	Weighting	**Emergency**	**Commercial**	**Hybrid**
Safe	.25	4	3	4
Fail-Safe	.20	4	3	4
Connected	.24	4	3	3
Builds off older tech.	.06	3	3	3
Maintainable	.11	3	2	2.5
Cost-effective	.13	2	3	3
Unweighted Total		20	17	19.5
Weighted Total		3.567	2.89	3.399

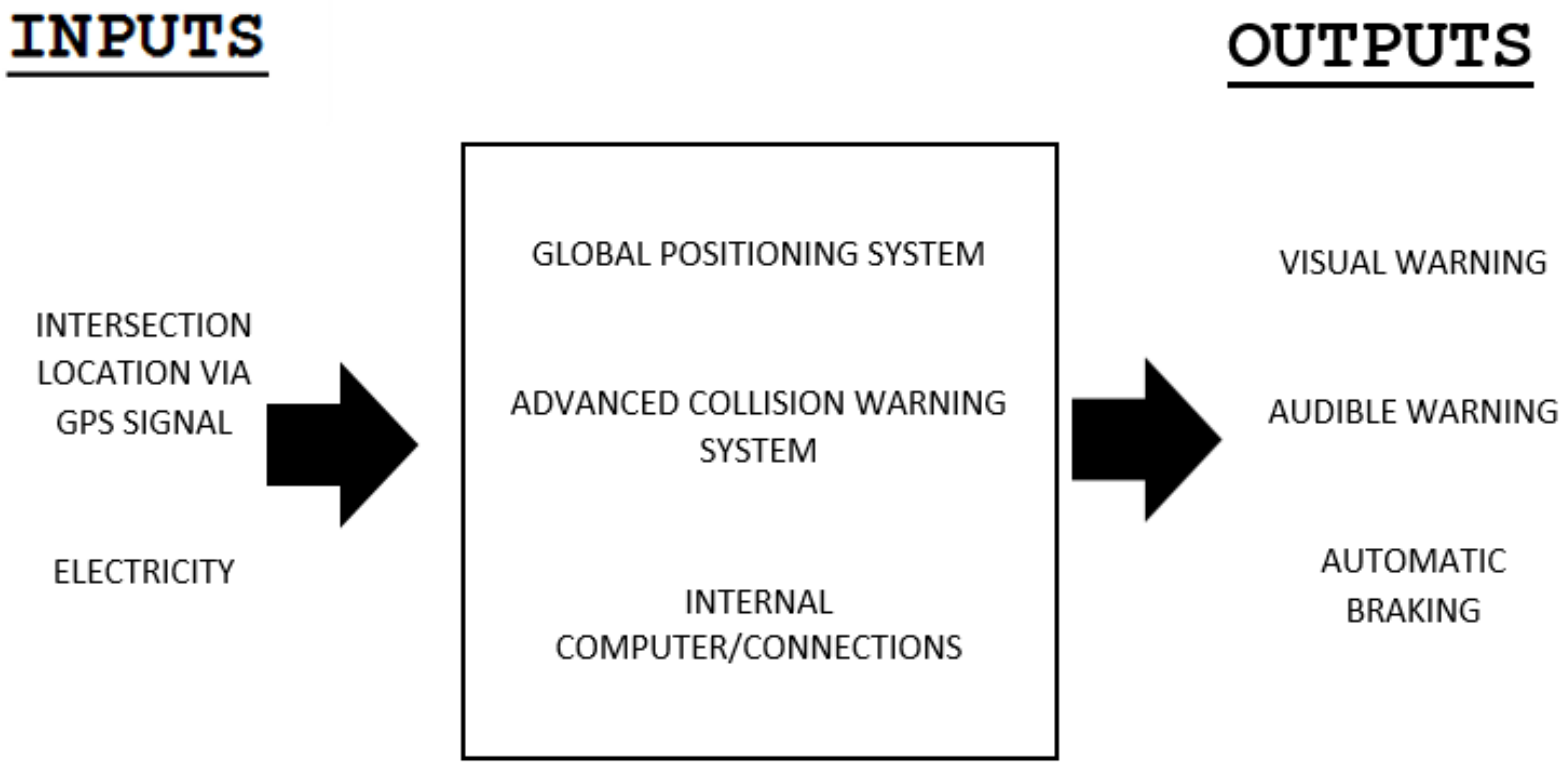
Based off the design selection matrix, the weighted total followed the order of:
1st: Emergency
2nd: Hybrid
3rd: Commercial

Once it was found that Emergency use was the best design, we refined the idea and changed the used technology to GPS systems and advanced collision warning systems rather than sensors in stoplights. This idea was put forth in order to cut out the middle-man of the traffic light to allow direct communication between the dispatch vehicle and the commuting vehicle.

Final Description:

E.V.I.S.T. is a link between global positioning systems and advanced collision warning systems. Using signals sent from emergency response vehicles, drivers will be notified both visually and audibly that such a vehicle is approaching the upcoming intersection. The main intention of the system is to warn the driver so that he/she will slow down at that time. If this is not enough, once the car gets too close to the intersection at too high a speed, the collision warning system will step in and slow the car down automatically keeping all persons in the vicinity of the intersection free of harm. People make mistakes, and that's a part of life. E.V.I.S.T.'s primary function is to keep drivers alert when they need to be at their best. Should that not be enough, the system will then take action. While humans are quite capable behind the wheel, the 96% of intersection related accidents that are caused by human error can be greatly reduced by taking that opportunity for error out of the equation. E.V.I.S.T. is a very innovative technology that brings a lot to the table. Based almost entirely on new programming for highly effective systems in modern cars, it will always have the ability to progress with time as newer and better versions and additional technologies come along. Being able to take a simple and effective technology and have it capable of working in all sorts of scenarios is a very useful advantage. While the original focus was based on intersections, taking it other places may be its greatest attribute. This is not just a fix for the now, but a fix for the future, and a fix that will save a great many lives.

Systems Diagram:



Scenarios:

While driving to work on a typical day, Roger receives a notification from his car's GPS that an emergency vehicle is approaching the intersection ahead of him and that he should slow down. Roger sees that he is speeding and slows down until the ambulance goes by and the notification goes away. He then safely drives the rest of the way to work and carries on with his day. After work Roger is tired and a little groggy when another notification comes from his GPS. This time he doesn't notice it and continues to go slightly above the speed limit. Once he gets too close to the intersection where a racing police cruiser is headed, the notification relays a signal to his car's assisted braking system and the car slows down automatically bringing Roger back from his daydream and allowing him to stay safe as the cruiser flies by. E.V.I.S.T. effectively notifies drivers of potentially dangerous situations at the

most dangerous sections of roadways anywhere. When notification is not enough, physical action is taken to keep the driver and other motorists safe. Because this technology is built off of GPS units, it could eventually be expanded for use on all sections of roadways without incorporating any new tools or programming. Also, because it all comes from the GPS units, a system failure will not damage the car in any way, and all functions will simply revert to the driver, which is how things currently work. An additional feature of E.V.I.S.T. is that it can also be implemented at areas such as frozen bridges and construction sites so that Roger can also be warned and protected in situations on all sections of road and where there is not a blazing siren trying to alert him.

Total Cost Analysis:

Taking full advantage of existing technology E.V.I.S.T. takes current GPS technology and connects them together as well as using current collision warning systems to slow down speeding vehicles. This means that the cost to integrate this system into the current market is significantly cheaper than most new high tech designs. Many modern cars come with a GPS integrated into the dash, or at least have a GPS tracker installed. Also, many people own a separate GPS that they use in their vehicles. The only cost to upgrade these systems would be to add the programming and connection to the vehicle so that the GPS can link to the brakes. Much of this falls under Non-Recurring Engineering (NRE) costs, while for upgrades the only consistent cost is the wire that would link the GPS to the car. External GPS systems cost on average $250-$300 for a reliable and up to date system. For new cars without an included collision warning system, the vehicle upgrade package runs on average around $3,000 that includes many safety systems on top of assisted braking. All in all, the highest an upgrade would cost would be around $3,500, but the average would be

significantly lower as most cars come with this technology already installed (4). This makes it more appealing to consumers, and attractive to car manufacturers.

Life Cycle Analysis:

According to the life cycle assessment done by Audi, life cycle assessment analyses the effect of a product on the environment during its entire existent by evaluating the following steps. Development Phase: the development of the product requires the creation of the software as well installing software. There will not be any raw material used except for electricity used by computer and GPS. The testing phase that the product must have requires raw material. Ambulance, police vehicles or other emergency vehicles are needed, testing also needs a regular vehicle and any Global Positioning System. The effect on environment caused by the progress of testing is extremely low because there only requires tiny amount of driving distances. Production Phase: the progress of producing requires existing GPS and collision warning system. There will not be any effect on environment. Use Phase: The product functions with the GPS and collision warning system. The only cost of functioning will be electricity. Recycling Phase: The recycling of the product will be replacing updated product to the old version. The old version of the software can be deleted completely. There is no effect on environment.

Conclusions:

In an attempt to make cars safer and better connected, multiple different concepts were explored to see how best to conquer the goals set by Delphi. In looking how to make cars the safest, the team looked at where roads are the most dangerous. Intersections hold

that title with ease, and contribute largely to accidents and deaths involving all sorts of people and vehicles. A large problem for states, cities, and towns across the country is how to make these death zones safer without shutting them down and creating a logistical nightmare. The team chose to work to solve this issue, and in listening to the voice of consumers elected to make the solution an emergency controlled system so that the people could retain the majority of their freedom.

Connecting emergency response vehicles with the public in order to keep everyone safe hit two of Delphi's goals, allowing the team to then solely focus on how to best design and incorporate such a system. Looking into radio transmitters and finally GPS connections allowed the team to create an extremely simple and effective system that would meet the desires of both the distributors and consumers, but while keeping total costs at an almost microscopic scale when compared to other designs. This also allowed a system to be created that could expand to cover many other areas in addition to intersections without extra add-ons being required. Taking full advantage of existing systems allowed the goals to be met and exceeded while keeping all parties happy. Keeping costs low, and benefits high was the goal of Team 5 in designing this system, and by creating a system that can replace itself, the solution is already here, and its name is E.V.I.S.T.

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