This is the physical prototype for VC1 which will be plugged into the head unit of the vehicle.
Executive Summary:

Delphi approached our team and challenged us to design a product that would be able to make vehicles either greener, safer, or more connected and if possible a combination of two or more. We were motivated by the task of developing something that could possibly save lives which forced us to think outside of the box. Using a customer need matrix and through conversations we came upon our final prototype; VC1. This prototype best fits the customer needs because it is a feasible concept that makes vehicles greener, safer, and more connected all in one.

Introduction and Problem Statement:

Vehicles play a very important role in everyone’s day to day activities. People should be able to travel and feel safe while still having conveniences such as being connected to the rest of the world while keeping their carbon footprint as small as possible. Unfortunately, technology is still lacking in this area of need. In 2012, there were 33,561 reported deaths in motor vehicle accidents. There have been small advances to reducing this number, but nothing has yet seemed to do the job. With green technologies making advances in other industries it is about time that there are some improvements in the auto industry. In 2012, 1,872 million metric tons of carbon dioxide were emitted from vehicles in the United States. There will always be room for improvement because in recent years, this number has only been growing. In response to these statistics and societal needs, our team has developed VC1. This product will make vehicles safer through connectivity and also reduce emissions through better routing and driving styles.
**Background:**

Delphi has a product that allows vehicles to be connected to the cloud and is able to be monitored from an outside source. This device is called the OBD-II and it will plug directly into the vehicle as long as it was manufactured after 1996. The device transmits a signal to an application that can be on a computer or phone and allows a business owner or parent to track the whereabouts of where the vehicle is. The app will alert them if the car travels outside the designated driving area, monitors fuel levels, and sends alerts about maintenance issues. This device can be used by businesses and parents to track their drivers to ensure no misuse of the vehicle is happening for a price of $250. This device uses the same method of connecting as our product would but the VC1 will serve a much different purpose. There are few products like this out on the market. The closest products are only applications on navigation systems that will only alert the driver of upcoming traffic. The VC1 will do this and much more by providing the driver with more important information that will improve their overall safety. There are no patents out that fit a description similar to our product, only broad patents that cover very vague concepts.

**Customer Needs:**

As seen in figure 1, the most valuable attribute of our product was determined to be the effectiveness of our product. We used this AHP matrix to help determine what should be the most important feature of our product. The VC1 will properly relay information to the customer in a way they will be able to understand without hesitation. Ease of use was also very important, so we developed a visual display that was easy to understand and does not require so much attention that it would distract the driver. The program is simple and straightforward to be as
convenient as possible. Our product is effective, easy to use, and cost effective. Our team researched the materials that would be needed to make a working prototype and made sure it was a reasonable price that could fit any budget.

Figure 1: This matrix shows the weights determined for the VC1 to fit the customer’s needs.

<table>
<thead>
<tr>
<th></th>
<th>Ease of Installation</th>
<th>Ease of Use</th>
<th>Cost</th>
<th>Size</th>
<th>Subtleness</th>
<th>Effectiveness</th>
<th>Durability</th>
<th>Total</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Install..</td>
<td>1</td>
<td>0.33</td>
<td>0.33</td>
<td>0.9</td>
<td>0.75</td>
<td>0.8</td>
<td>1</td>
<td>5.11</td>
<td>0.09</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2.9</td>
<td>1.5</td>
<td>1</td>
<td>2.5</td>
<td>11.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Cost</td>
<td>3</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>0.5</td>
<td>0.25</td>
<td>1.25</td>
<td>8</td>
<td>0.14</td>
</tr>
<tr>
<td>Size</td>
<td>1.11</td>
<td>0.34</td>
<td>0.67</td>
<td>1</td>
<td>0.5</td>
<td>0.3</td>
<td>1.1</td>
<td>5.02</td>
<td>0.09</td>
</tr>
<tr>
<td>Subtleness</td>
<td>1.33</td>
<td>0.67</td>
<td>0.5</td>
<td>0.6</td>
<td>1</td>
<td>0.8</td>
<td>1.75</td>
<td>6.55</td>
<td>0.12</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1.25</td>
<td>1</td>
<td>4</td>
<td>3.33</td>
<td>1.25</td>
<td>1</td>
<td>2.5</td>
<td>14.33</td>
<td>0.25</td>
</tr>
<tr>
<td>Durability</td>
<td>1</td>
<td>0.4</td>
<td>0.8</td>
<td>1.81</td>
<td>0.57</td>
<td>0.4</td>
<td>1</td>
<td>5.98</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Grand Tot: 56.39

Concept Generation:

We began our concept generation by first exploring the three mega-trends that are the goals of Delphi, which are Connectivity, Green, and Safety. We decided that it would be most efficient to cover at least 2 of the 3 megatrends. We decided that through the improvement of connectivity we would be able to improve all three mega-trends. We then had to determine what would be the most helpful to connect vehicles to. This led to us determine cell phones, other cars, and eventually traffic lights.

Each variable of connectivity had benefits to a vehicle. By connecting to other cars we would make vehicles able to be more efficient by finding different routes based on the flow of traffic. The use of cell phones were critical to this device, because it allowed for updates on traffic, improved user interface, and stopped users from using their phone for texting. This is important because in the present day the majority of people have phones that will be able to interact with our device.
Once we decided on what to interact with we had to determine what kind of user interface would be the most efficient way to convey our data to the user. We explored various hands free devices that would keep a person from using their cell phone. Items such as Google Glass, Touchscreen, Dashboard display units, and a windshield display were looked at and eventually it was decided that the easiest to integrate into the most vehicles, and safest to use was the touchscreen dashboard display units in most new vehicles.

**Concept Selection:**

Our choices for our final design were various ways of connecting our device into the head unit in order to display the user interface onto the touchscreen. One design was to use a simple USB that would be simple for the user to plug into the vehicle and use. Our next design was to wire the device into the head unit inside of the vehicle. This would be harder to install, but it would be more reliable as it would be harder to remove when compared to the USB. Our final design was fully wireless, which would require Bluetooth to connect to the users’ phone and the vehicle. A fully wireless device would be less reliable in case of the connection dropping. We determined that the best trade-off between all of our customer needs was the USB input device as shown in table 1.

**Table 1:** This is showing our design selection matrix.

<table>
<thead>
<tr>
<th>Features [weight]</th>
<th>1. Ease of Installation [0.09]</th>
<th>2. Ease of Use [0.20]</th>
<th>3. Cost [0.14]</th>
<th>4. Size [0.08]</th>
<th>5. subtleness [0.12]</th>
<th>6. Effectiveness [0.25]</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design 1: USB Plugin</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>23</td>
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<td></td>
<td>0.45</td>
<td>0.80</td>
<td>0.56</td>
<td>0.32</td>
<td>0.36</td>
<td>0.79</td>
<td>3.24</td>
</tr>
<tr>
<td>Design 2: Wired into Head Unit</td>
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<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>0.18</td>
<td>0.80</td>
<td>0.42</td>
<td>0.40</td>
<td>0.60</td>
<td>0.75</td>
<td>3.15</td>
</tr>
<tr>
<td>Design 3: Wireless Device</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>0.36</td>
<td>0.60</td>
<td>0.28</td>
<td>0.32</td>
<td>0.48</td>
<td>0.75</td>
<td>2.79</td>
</tr>
</tbody>
</table>
Final Design:

The USB plugin was selected because it had the highest total value in our design selection matrix. Our most important feature that we determined through the customer needs scoring matrix was that the device be effective. We determined that all of our designs would be equally effective as they would all be able to do the required job, but they all had some possible flaw or possible point of failure. The second most important feature was that the device be easy to use. In this category we found that the USB plugin would be easy to use on the touchscreen as it would simply be to launch the app on the users’ phone and go. Our next most important feature was the cost of the device, which we found would be the least expensive option of our three proposed ideas. The subtleness of the device was the next most important because customers would not want to buy the device if it took up a lot of space. The final design scored the lowest of all of our designs in this category because the device would not be hidden away as easily as the other two designs. However this was not weighted too heavily in our design. The penultimate weighted feature was the ease of installation. The USB would be extremely easy to install because all that it would require is for the device to be plugged in to the users head unit. After plugging the device in all that needs to be done later is to open the app on the users’ phone. Our final lowest weighted feature was the size of the device. The selected device would be quite small and therefore scored well here, but this feature was not as important when compared to other features.
3D Model and Images of Interface:

Our decided model was a 1x1x4 plastic box with a USB port and antenna in order to easily connect to the users’ phone and make it easy to connect to the vehicle through the USB as seen in figure 2. The use of a USB port was used so that it would be compatible with a variety of other ports by switching the cord that is used. The USB adaptive cord would be inexpensive and
able to be changed to connect into the variety of ports that are used in vehicles. Also the USB allows the device to be more durable and less likely to become unusable by a connected wire disconnecting.

Figure 2: This is a solid works model of our product.

The user interface that would be shown in the cars touchscreen is shown in a sample situation as shown in figure 3. It displays a variety of possible alternate routes and the effects of all of the different re-routing options possible. This information would be collected by other vehicles, GPS locations, and communication with traffic lights.
Concept of Operations:

During normal driving when approaching a traffic light, while the light is green the driver will drive normally up to the light. The product will communicate with the traffic light to determine how long the light has been green and how much longer the light will remain green. The device will then determine if while maintaining the drivers current pace if they will be able to make it through the light before it turns red. If the driver can travel through safely there will be no alerts and the driver will proceed as usual. However if the driver will not be able to make it through the light safely the system will alert the driver so that they can begin to smoothly break early, which will reduce crashes from sudden stops, and save the driver fuel.

When a driver approaches a traffic light, which is currently red the device will communicate with both the traffic light and other vehicles in traffic at the light. Through
communication with the traffic light the device will determine how long it will be until the light will turn green. Through communication with other vehicles the device will determine how long a vehicle has been waiting at the traffic light. If the traffic light is about to turn green and the other vehicles have been at the light for one light cycle or less, then the system will alert the driver of the red light, but not offer re-routing information to avoid heavy traffic. However if vehicles have been at the traffic light for more than one light cycle the device will alert the driver of the red light and the traffic and offer re-routing information that will allow for the driver to save time and/or fuel by avoiding areas of heavy traffic.

In the event that the device were to fail there are two possible situations that would occur. Either the device would fail to notify the driver of an impending stop, or the device would falsely alert the driver to stop. If the device fails to notify the driver of an impending stop the driver would have to use their own discretion of whether or not to begin slowing down for a stop light, or to find a way around traffic. This may result in sudden stops at traffic lights, which may result in collisions. If the device were to falsely alert a driver to stop the driver may slow down traffic by slowing down at a light which would remain green. This could result in a collision due to following traffic not expecting the driver to slow down.

**Cost and Feasibility Analysis:**

When taking cost into consideration we based our material prices off of what is similar to it in the market in its physical performance as well as operational performance. We found that a good estimate of our physical material cost would approximate to $35 per unit. We also determined that it would take 3 engineers roughly 2 months to take this product from spreadsheets to a working prototype. At 45/hour for engineers it would cost $43,200. As for our application that will show up in the user’s car, we would hire an outside computer development
company to make the application. At an estimated rate of 33/hour and 4 team member working on the project for 2 months, the estimated cost would be $42,240. In total our cost analysis would put our total cost at $85,475. This device will be marketed to those who are buying models of cars from the same manufacturer that has allowed Delphi to include this device in the manufacturing process.

As $35 is a relatively low price, and since it is a one-time cost, and no external costs that will develop during the device's usage, the customer will find that the device will begin to save money after approximately 1500 miles of driving, or an estimated 1-2 months. This is due to the large fuel savings that this device can offer, as it enables the driver to maximize optimal cruising speed through traffic avoidance, as well as suggested driving methods displayed on the touchscreen. This approximation was found through the average cost of a tank of gas, of $43.50, multiplied by the estimated percentage of efficiency that is gained by the use of the device, which is 16%. The resulting cost was divided by the cost of the device, to find how many tanks of gas the driver would use before the product breaks even. The number of tanks, approximately 5, multiplied by the average tank capacity of a car, 300 miles, equals the average distance driven before the product breaks even.

The product will be included with all models of the cars of the manufacturers that are working with Delphi. Although this product not be required to be used by the customer, the customer will be forced to pay for the device as well as the car, to own the vehicle. The government should set a maximum price increase of no more than $100 for the vehicle, with the device included.

This product is very feasible for the automakers to include in their newest line of cars, as their overall profits will increase, the manufacturing process is minimally more expensive, and
most customers will buy the vehicle, as a $100 increase in price will not deter serious car buyers from these newer models. One issue of concern is privacy issues associated between customers, and customer to the government with the GPS capabilities on the device. Most customers will not wish that governments can track drivers when the device is on, as well as drivers knowing where other drivers are going. The device will best be controlled by only the user, as the GPS capabilities will only be in use when the car is on, and the user can disable the GPS at will, using the application installed onto their cell phones. If the government is able to regulate the use of these devices, many potential customers will search for alternative products with more privacy.

**Life Cycle Analysis:**

The life-cycle of a car can be significantly affected based on efficient driving methods as seen in table 2. With the assistance of an internal connected interface system, the driver can be notified of fuel-burning phenomenon, such as traffic congestion, time until traffic lights change color, and at what rates to accelerate. This interface system enables the driver to minimize acceleration, braking, and idling, and maximize coasting, and maintain cruising speed, to ultimately increase the life-cycle of the vehicle. The main purpose of the device is to alert the driver of any inefficiencies of the vehicle’s features, such as tire pressure, oil, and fluids, as well as new driving routes or strategies that could maximize the utility of the vehicle without damaging the engine or burning excessive amounts of fuel. Our group developed features of the device involving the physical handling of the car that would extend the life cycle of the vehicle, and maximize the utility of the car. The device displays optimal driving method suggestions that can be either used or ignored by the driver, in order to prolong the longevity of the car's engine and components. The device itself is a 1" by 1" by 4" box composed of a hard polymer material for the outer casing, and various circuit boards and nanotechnology on the interior, with a USB
port and an antenna made out of a conducting material, such as copper. These materials were used, as they were the most inexpensive choices, and are reliable in terms of durability. These materials make a minimal impact on car production, as the device is so small compared to the vehicle, that manufacturing methods will remain largely unchanged. The materials themselves do not affect the use of car, only the function of the device can make an impact on the car.

Table 2: This shows the increase in efficiency of driving features that affect car life-cycle.

<table>
<thead>
<tr>
<th>Driving Features (with weights)</th>
<th>Acceleration/Idling/Braking x 0.3</th>
<th>Optimal cruising speed x 0.2</th>
<th>Internal features (Tires, oil, fluids) x 0.1</th>
<th>Fuel efficiency (from suggested driving from device) x 0.4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated efficiency increase (%)</td>
<td>15%</td>
<td>15%</td>
<td>5%</td>
<td>20%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Average car life = 11.4 years
11.4 x 115% = 13.2 years
13.2 - 11.4 = 1.8 year longer life cycle

Conclusions:

The main objective of this product was to implement a device into a car that would advance the megatrend of connectivity between cars, without impeding on the impact of the safety, and "green" megatrends. The product is a small box that is connected to the head unit of cars, so that the user interface will be displayed on the touchscreen in newer models of cars. The device has a USB port that can used to be universally plugged either directly into the vehicle, or into an adapter, then the vehicle. There is also an antennae on the device which connects to the data on a cell phone, and can aid in car-to-car connectivity.
The advantages of this design is that it is relatively inexpensive, is small and compact and won't cause physical interference with the driver, and the installation of this device would be very simple. Once the device is plugged into the vehicle and the driver installs the cell phone application, the device will be able to connect to other cars, and provide input regarding traffic patterns and GPS. Also, the device excels in terms of subtle notifications and warnings, as the alerts on the touchscreen are easily visible to the driver, yet do not force the driver to commit his/her attention to the touchscreen for a long period of time. There is also a wide range of features that this device is capable of detecting, such as possible traffic on routes ahead, timing of traffic lights, and notifications of when there are considerable terrain changes, such as steep hills, or sharp turns ahead.

There are some shortcomings to this method of car connectivity, such as the fact that the driver's cell phone's data is used to connect to other phones in other cars. Although the driver can disable this feature of the device, it would have to be when the current trip has been completed. Also, for first time users who are not well acquainted with the user interface, it can be difficult to initially navigate through the different displays on the touchscreen, or get accustomed to the driving method suggestions that the device offers. Regarding the physical design, there may be a problem with where the device will be placed, as there is no designated storage unit for the device to be held. Perhaps in future design, there will be a mounted device holder within the driver's reach.

Our group understood the importance of developing an innovation for a specific area, or megatrend, while also not interfering with that of other megatrends, but improving them as well. We learned that a product can have more than all of the technologies required to serve its intended purpose, but it must be accessible and marketable to all types of consumers, or else the
product cannot be widespread. This device is intended to be implemented in all models of vehicles of any and all car companies that allow the production, so the product must be able to be used universally by all customers, as they will now be paying extra for the next line of cars from these companies.

References:

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http://www.wikihow.com/Extend-the-Life-of-Your-Car