

Sleep Prevention System



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Team 3

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¹⁴ <http://enddd.org/safety-on-the-road/drowsy-driving-1-in-25-fall-asleep-at-the-wheel-according-to-cdc-report/>

Executive Summary

Delphi challenges students to create a part or accessory to a car, small truck or small van that will make it safer, greener, or more connected. The goal of the project was to focus on one of the megatrends in vehicle technology. Group 3 developed three different design concepts on parts or accessories initially. The initial concepts that the group compiled were: 1) the improvement of battery efficiency in cars as well as heavy duty trucks. 2) developing a multi-energy resource vehicle that can use hydrogen, electric, wind, and solar energy. This would be an extremely green vehicle. 3) developing a substance identifier/text blocker to prevent drivers that are under the influence from being able to start and drive their car. The same would apply to texters. However, after taking surveys, the group found another idea to add to the list: a system that keeps drivers awake and alert. To determine which of the four ideas to pursue the group scored each one of the ideas using a design selection matrix. After doing so the group decided to create a sleep prevention system for drivers at the wheel. This would involve a heart rate monitor, and a camera that measured the motion of the driver in the seat, and eye movement. Using these sensors, the Sleep Prevention System can create a safer driving experience for people everywhere.

Introduction

The purpose of this project is to improve the safety of vehicles, and Group 3 focused on preventing fatigue related accidents. The Sleep Prevention System will ensure that accidents will no longer happen due to drivers falling asleep at the wheel. The system is made up of two sensors: a heart rate monitor (located in the steering wheel), a camera built into the dashboard that monitored the driver. The heart rate monitor will detect whether or not a driver is asleep based off of their heart rate. The camera would count how many times a drivers head bobs and the driver's blink speed and frequency. When a driver begins to fall asleep, not only will alarms go off, but the car will go into what is called Auto-Pilot mode. This mode locks the steering and gas for fractions of a second so that the driver does not swerve off the road if they are startled by the alarm. The Sleep Prevention System will allow the driver to pick how they would like to be woken up (i.e. vibrations, different sound options, etc.). All of this will allow the driver to never worry about falling asleep at the wheel again.

Problem Statement

Many drivers that fall asleep at the wheel, a problem which has taken the lives of many innocent people. Every year, thousands of catastrophes are caused by driver sleepiness and fatigue. The National Highway Traffic Safety Administration approximated that at least 1,500 deaths, 71,000 injuries, and \$12.5 billion dollars are lost every year to fatigue caused accidents.¹ Anyone on the road is at risk of fatigue related accidents. This issue must be fixed and cars must be made safer so that no further accidents occur.

Research

Initially, research was done to analyze the feasibility of all the design concepts. The Group wanted to focus on an idea that could most improve the overall driving experience. The research began with the improvement of battery efficiency in cars. Currently, hybrid car batteries are not universally accepted because of lower speeds and smaller range than gasoline engines. Research has been done to create better batteries. One of the biggest problems to battery inefficiency is the massive weight of a car battery, with some weighing up to 120 lbs⁷. Several car companies are researching the idea of using lithium ion batteries and lead acid batteries in future hybrid vehicles.⁸

The major push to design an extremely green car was to utilize hydrogen fuel cells. Hydrogen fuel cells react hydrogen atoms with oxygen to produce water. When the hydrogen atoms combine with the oxygen atoms, they pass through a proton exchange membrane that only allows protons to circulate through the circuit.⁹ The ions are then used as electricity and the car produces work. Hydrogen fuel cells are beginning to become more popular in California area, and have the appeal of not producing any carbon emissions. However, it is still a relatively new and complex idea.

Research was done to see the importance of preventing drivers from texting while driving. In 2011, nearly a quarter of all accidents were calling or texting related.¹⁰ Texting while driving is six times more likely to cause an accident than while intoxicated. It is a dangerous activity.

Finally, research was completed on drowsy driving using online sources and websites. There are many available sleep prevention products. These products tend to implement only one type of sleep tracking system. Some current sleep prevention products that are available or in development include a project from Nottingham Trent University, sleep prevention apps such as the Café Amazon Drive Awake app², and eye-tracking technology developed by Seeing Machines.

Every year, thousands of catastrophes are caused by driver sleepiness and fatigue. The National Highway Traffic Safety Administration approximated that at least 1,500 deaths, 71,000 injuries, and \$12.5 billion dollars are lost every year to fatigue caused accidents. Anyone on the road is at risk of fatigue caused accidents. One in four adults have reported that they personally know someone who was involved in a fatigue related accident.¹

A system is being developed by Nottingham Trent University, which uses an electrocardiogram in the driver's seat to track the driver's heart rate. As the driver's heart rate begins to slow, or in extreme instances, stop, the car takes control from the driver. The car is also programmed to give the driver alerts before the driver falls asleep or loses consciousness.³

Many different smart phone apps are available to help prevent sleep. One prevalent app is called Café Amazon Drive Awake. To use this app, the smartphone must be mounted on the windshield and uses the camera to track the driver's head and eye motion. As the driver becomes drowsy, the app alarms the driver through sound and uses GPS technology to direct the driver to the nearest sponsored coffee shop.²

Seeing Machines developed a similar sleep detection technology for construction vehicles. A computer, a camera, an accelerometer, and two separate light sources are installed into the vehicle. As the driver's eyes close for longer intervals of time, the vehicle will shut down

and the system notifies the construction vehicle's home office and a dispatcher will ask if the driver is ok. ⁴

The following table is composed of prices and materials that can be used to produce the product being made:

Table 1: Specific Data Based on Prices (December 12, 2014)

Product	Cost
Heart-Rate Monitor ⁶	\$50
Eye-Tracking Camera ¹¹	\$150
Alarm/Vibrating System ¹²	\$50

Calculations

Scenario: When driving 60 mph, and the driver is following another car by 20 ft., how fast must a system react if the person is asleep and car in front slams on the breaks?

-Distance for Followed Car to Reach a Stop:

-breaking distance: 172 ft¹³

-Distance for Following Car to Reach a Stop:

-breaking distance + 20ft = 172 ft. + 20 ft. = 193 ft.

-Average Brake Deceleration: 32 feet per second per second

- 60 miles per hour = 88 feet per second

Equation: $y = -32t^2 + 88t + 193$

$$0 = -32t^2 + 88t + 193$$

$$t = 4.2 \text{ seconds}$$

Customer Needs

First and foremost, the sensors used to determine whether the driver is (falling) asleep need to be reliable and accurate. If they do not work, then there is no point in buying the product. The sensors also need to have a somewhat limited range of what is considered asleep. A vehicle that initiates Auto-Pilot mode because the car thinks the driver is asleep despite him/her being awake can potentially cause serious damage. Lastly, the sensors must not impact the driver's overall ability to drive.

Concept Generation

To reach the final decision of a Sleep Prevention System Group 3 first looked at what technologies Delphi was already testing and or creating. Next, the group discussed which of Delphi's three goals they wanted to mainly focus on. Then the group came up with three ideas, two of which focused on improving vehicles impact on the environment, and one that focused on

safety. The three concepts were: 1) the improvement of battery efficiency in cars as well as heavy duty trucks; 2) developing a multi-energy resource vehicle that can use hydrogen, electric, wind, and solar energy, and 3) developing a text blocking and or inebriation detection system that would keep drivers safe and focused on the road.

Concept Selection

After creating the initial three ideas the group created a survey to gather people's opinions and input on the project concepts. The survey results revealed that while people enjoyed the idea of a greener car, because it was interesting and seemed like the most possible innovation in the coming years, what they enjoyed more was the idea of a safer car. Many had known someone involved in a vehicular accident and any improvement that would prevent such an accident was appealing. The survey also included a section that allowed participants to write their own ideas for the project down. One such idea was a sleep prevention system that would sense a driver's heart rate and alert them when it got too low. The group saw the value of this idea and from there thought of three different ways to make a sleep prevention system. The three approaches were: 1) a sensor that detected how many times and how long a driver blinked; 2) a seatbelt that sensed a driver's heart rate, 3) a steering wheel that sensed a driver's heart rate coupled with a camera that observed how many times and how long a driver blinked. The use of a design selection matrix the group decided upon the third idea, and an Analytical Hierarchical Process (AHP) was used flesh out the final details of the project.

Final Description

The final design is a steering wheel with sensors on its rim that monitors the heart rate of the driver, and a camera that would monitor how frequently and the duration of a driver's blinks as well as the head movements of the driver. These three variables would be computed and used to measure if a driver was fully awake, beginning to doze, or heading toward loss of consciousness. When the computer reached the decision that the driver was initially falling asleep it would emit a small alarm to try and wake the driver. If the driver did not respond to the initial alarm the computer would then engaged the autopilot by locking the steering and the speed for a fraction of a second. From there the vehicle would then either produce an alarm or flash of light to try and wake the driver. Now even if the driver is startled back awake the car is under control and the jolt that woke the driver will not cause him to veer off the road.

Total Cost Analysis

Z_T: \$250.00 (see Table 1)

Cost of Parts per Product: \$106.84

Estimate of Hourly Salary for an Engineer: \$40.00/hour

Assume 4 engineers would be required to create and test all of the components of the product

Cost of Monthly Wages: \$25,600.00

Loaded Labor Costs: \$38,400.00

Assumed Cost to Change Vehicle Production Line: \$250,000.00

NRE: \$314,000.00

Approx. NRE Cost per Product: \$15.70

Assembly Wages: \$40.00/hour

Total OEM Cost: \$325.08

Final Cost to Buyer: \$975.24

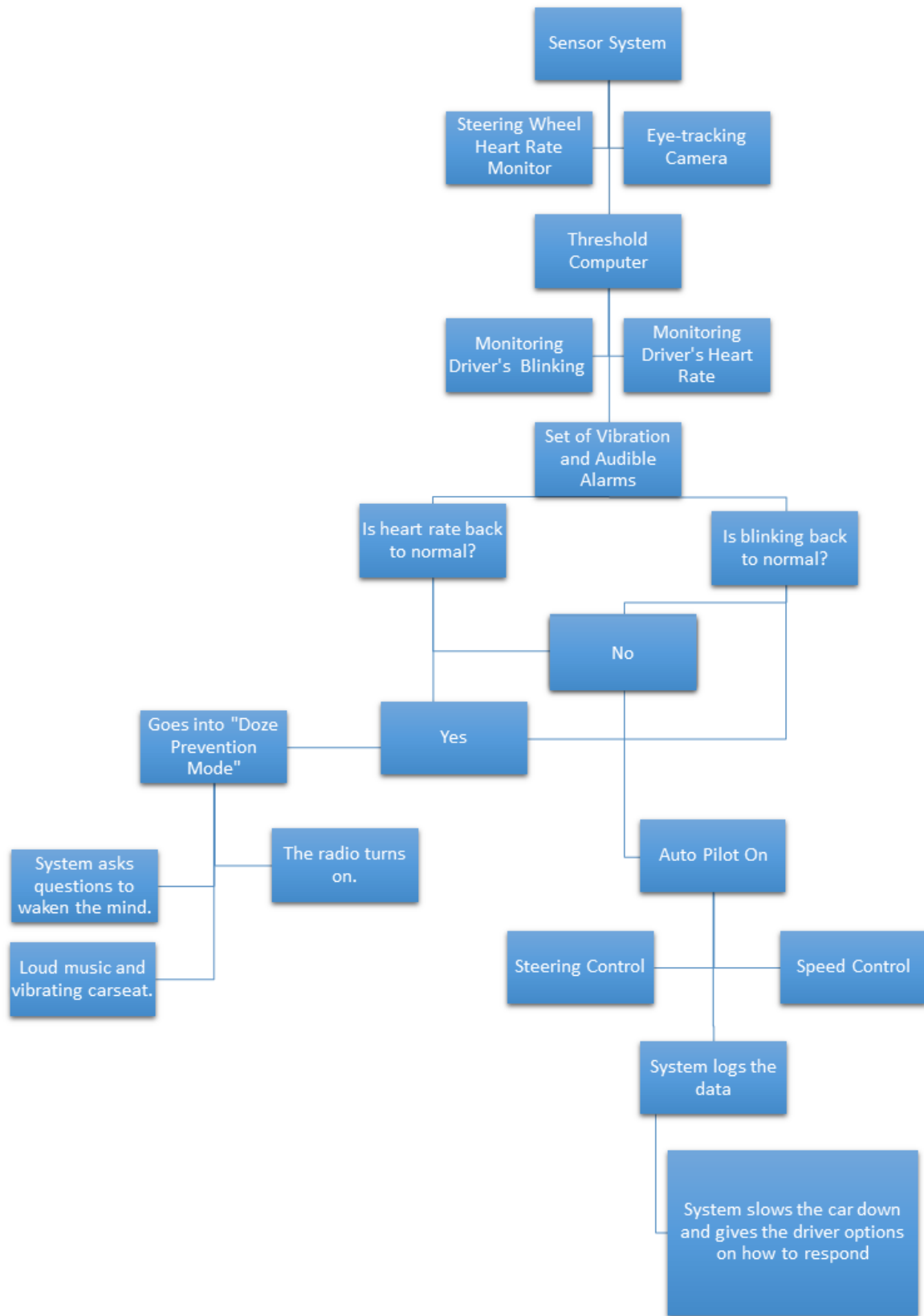
Scenarios

A driver is getting ready to drive to work. This driver is very tired, having only had three hours of sleep. In addition, the driver's route to work is mostly a large, monotonous flatland and typically takes over 30 minutes. The driver is getting sleepy, with the driver's eyes struggling to stay open, and slight swerving back and forth on the road. However, before the driver can fall asleep, the eye detector and the heart rate monitor realize that the driver is losing consciousness. The system first makes an audible alarm and warning. If no change in driver behavior is detected, the system goes into Autopilot and continues trying to awake the driver. The driver awakes, hastily grips and swerves the steering wheel (but nothing happens because of the Autopilot, which locks the steering wheel so it stays in lane and maintains the previous speed for a small duration), then begins driving as normal again after the car realizes the driver is awake and unlocks the wheel. Crisis averted, thanks to the keep-awake car!

Life Cycle Analysis (LCA)

This product is expected to last the entire life cycle of the car. There would be a very minimal edition of any components to the car save the camera and heart rate monitor. The creation of these parts would have little to no impact on the environment, they would not need maintenance after installation, and could be easily recycled or disposed after use. The large part of the system is the programming done to already available resources in the vehicle. With the entire system itself using only a small amount of energy the Sleep Prevention System would not have any negative effects towards the environment.

System Diagram



Appendix A

Survey Given For Idea Selection

The Delphi Project: The goal of this project (sponsored by Delphi) is to create safer, greener, and more connected vehicles in the near future.

1. Read the following 3 ideas:

Idea 1: The improvement of battery efficiency in cars as well as heavy duty trucks.

Idea 2: Developing a multi-energy resource vehicle that can use hydrogen, electric, wind, and solar energy. This would be an extremely green vehicle.

Idea 3: Developing a substance identifier/text blocker to prevent drivers that are under the influence from being able to start and drive their car. The same would apply to texters.

2. Age: _____

3. Gender (Circle One): Male Female Other

4. Do you have a driver's license? (Circle One) Yes No

5. How long have you been driving? _____

6. Do you own a car? (Circle One) Yes No

7. Rank the ideas read in problem 1 (1 being the best idea - 3 being the worst idea):

_____ Idea 1 _____ Idea 2 _____ Idea 3

8. Why did you rank the ideas in problem 7 that way?

9. What would you be willing to pay? (Circle One) A lot A little

10. Do you have any new ideas? If so, explain.

11. What would you like to see in the next ten years?

Appendix B

Design Matrix for Delphi

Design Features/Requirements	Weights	#1	#2	#3
Comfortable	0.09	3	5	5
Safe	0.12	3	3	5
Life Cycle Assessment	0.15	3	3	4
Autopilot	0.17	4	4	4
Options of Methods	0.1	2	2	4
Simple Design	0.08	4	5	3
Accurate Detection	0.28	3	4	5
Total Without Weights		22	26	30
Total With Weights		3.12	3.5	4.37

Idea 1: The seatbelt has a heart-rate monitor. When the heart rate monitor detects a slower heart beat, it will buzz to wake you up. It will also put the car in an autodrivesystem to keep you from jerking when you become alert.

Idea 2: A camera is installed looking at the driver that tracks the driver's eyes. When the driver starts to fall asleep, an alarm will go off or the seat will vibrate. The car also has an autodrivesystem.

Idea 3: This idea uses both the camera and the wheel has a heart rate monitor. When the person is falling asleep, the car is put into autopilot and steers the car off the road. There is a computer that keeps track of the number of times you fall

Appendix C

Analytical Hierarchical Process

[illegible]

References

1. "Drowsy Driving: 1 in 25 Fall Asleep at the Wheel According to CDC Report | EndDD." *EndDD Drowsy Driving 1 in 25 Fall Asleep at the Wheel According to CDC Report Comments*. N.p., n.d. Web. 21 Nov. 2014. <<http://enddd.org/safety-on-the-road/drowsy-driving-1-in-25-fall-asleep-at-the-wheel-according-to-cdc-report/>>.
2. "Cafe Amazon Drive Awake App Alerts Sleepy Drivers." *Ubergizmo*. N.p., n.d. Web. 21 Nov. 2014. <<http://www.ubergizmo.com/2013/08/cafe-amazon-drive-awake-app-alerts-sleepy-drivers/>>.
3. "Car Seats Know That You're Falling Asleep : DNews." *DNews*. N.p., n.d. Web. 21 Nov. 2014. <<http://news.discovery.com/autos/drive/car-seats-know-that-youre-falling-asleep-140715.htm>>.
4. "Eye-tracking System Monitors Driver Fatigue, Prevents Sleeping at Wheel (Wired UK)." *Wired UK*. N.p., n.d. Web. 21 Nov. 2014. <<http://www.wired.co.uk/news/archive/2013-05/28/eye-tracking-mining-system>>.
5. "Facts and Stats." *Drowsy Driving Stay Alert Arrive Alive RSS*. N.p., n.d. Web. 18 Nov. 2014. <<http://drowsydriving.org/about/facts-and-stats/>>.
6. "How Much Does a Heart Rate Monitor Cost? - CostHelper.com." *CostHelper*. N.p., n.d. Web. 21 Nov. 2014. <<http://health.costhelper.com/heart-rate-monitor.html>>.
7. "5 Ways Hybrid Battery Packs Are Being Improved - HowStuffWorks." *HowStuffWorks*. N.p., n.d. Web. 12 Dec. 2014. <<http://auto.howstuffworks.com/fuel-efficiency/hybrid-technology/5-hybrid-battery-pack-improvements.htm#page=1>>.
8. "The Hybrid Car Battery: A Definitive Guide - HybridCars.com." *HybridCars.com The Hybrid Car Battery A Definitive Guide Comments*. N.p., n.d. Web. 12 Dec. 2014. <<http://www.hybridcars.com/hybrid-car-battery/>>.
9. "Polymer Exchange Membrane Fuel Cells - How Fuel Cells Work." *HowStuffWorks*. N.p., n.d. Web. 11 Dec. 2014. <<http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell2.htm>>.
10. "PowerShot SX170 IS Black." *Canon*. N.p., n.d. Web. 12 Dec. 2014. <http://shop.usa.canon.com/shop/en/catalog/cameras/powershot-sx-series-digital-cameras/powershot-sx170-is-black?utm_source=google&utm_medium=Product_Search&utm_campaign=Google_Product_Feed&cm_mm_c=GA-_-_-G_Canon_Product%20Listing%20Ads-_-33060>.
11. "The Sharper Image - Official Site." *Alarm Clock for Heavy Sleepers @ Sharper Image*. N.p., n.d. Web. 12 Dec. 2014. <http://www.sharperimage.com/si/view/product/Alarm-Clock-for-Heavy-Sleepers/200860?p=plist2470005&gmkt=true&p=plist2470005&utm_source=Google&utm_medium=CPC&utm_campaign=NonBranded&Keyword=&cm_mmc=CPC-_-Google-_-NonBranded-_-PLA&adpos=1o1&creative=51054447743&device=c&matchtype=&network=g&gclid=COLVqc_8v8ICFRBo7Aod_B0A0w>.
12. "Texting and Driving Statistics." *Texting and Driving Statistics*. N.p., n.d. Web. 11 Dec. 2014. <<http://www.textinganddrivingsafety.com/texting-and-driving-stats/>>.
13. "Vehicle Stopping Distance And Time." *Vehicle Stopping Distance And Time*. N.p., n.d. Web. 12 Dec. 2014. <<http://www.csgnetwork.com/stopdistinfo.html>>.
14. "Drowsy Driving: 1 in 25 Fall Asleep at the Wheel According to CDC Report | EndDD." *EndDD Drowsy Driving 1 in 25 Fall Asleep at the Wheel According to CDC Report Comments*. N.p., n.d. Web. 14 Dec. 2014. <<http://enddd.org/safety-on-the-road/drowsy-driving-1-in-25-fall-asleep-at-the-wheel-according-to-cdc-report/>>.