Road Safe Phone Case

PROJECT PLAN

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1 Introduction

1.1 Acknowledgement

This project has been made possible by the Iowa State University ECpE Department's professors and resources. The team is grateful to have the opportunity to receive technical advice and guidance from Dr. Diane Rover. She has served as a knowledgeable point of contact as the project, providing valuable information to help the project progress. The individual that proposed this life-saving device, Christine Shea-Hunt, is also the sole provider of financial aid for the project materials. The team is committed to using the funds wisely, so that the road safe case will be created efficiently and inexpensively. The Electronics Technology Group (ETG) has also provided the team with equipment and advice that have improved the product's design.

1.2 Problem and Project Statement

Phones have become an integral part of everyone's lives. Communication, entertainment, and organization are only a few of the advantages a phone offers. However, this small device can also serve as a fatal distraction. According to the Centers for Disease Control and Prevention, in the U.S. alone, approximately 9 people are killed and more than 1,000 injured in crashes involving distracted drivers daily (2017). Talking on the phone, sending a text message, using navigation systems, and more are just a few ways that drivers easily endanger themselves and others on the road.

To help make the road a safer place, the amount of distracted drivers must be reduced, which can be accomplished by removing the temptation of a phone. The approach to this problem will be to create a device that locks away the keys to car, unless the phone is swapped for the keys. Progress towards safe driving can be achieved by creating a two-sided case, in which one of the two sides always remains locked. One side will securely store the keys until the other side detects, verifies, and secures the driver's phone. Then, to reacquire the phone, the keys would need to be returned, verified, and secured in the case. In case of emergency, access to either the phone or keys will be made available, and the case can be reset to function normally and protect the drivers and the roads once again.

1.3 Case Diagram

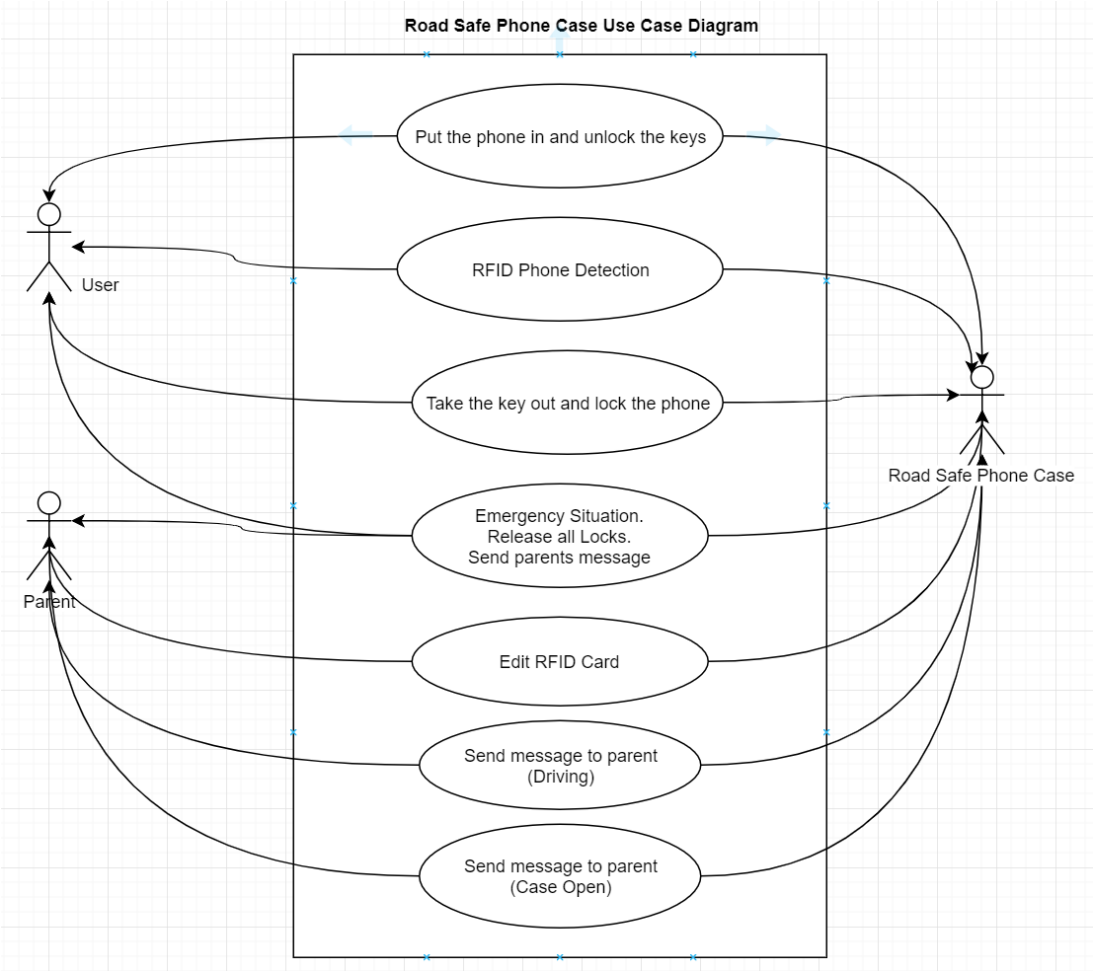

Figure 1: Use Case Diagram

1.4 Operational Environment

The road safe case will mostly operate in a car, which should endure various temperatures. The case will need to be able to withstand normal and hazardous weather conditions inside a car, whether it be extreme cold or heat. The case should also fit in a spot within the car so that it remains stationary while in a mobile vehicle. The interior of a car also often gathers dust and at times trash, though this does not pose a threat to the case unless there was direct interaction with the case. Other potential environments are inside a home, because the case will portable and may be moved to other locations if the user needs to take the case to a parent to reset it or for other reasons. However, the case does not have functions that primarily relate to being outside of the car environment.

1.5 Intended Users and Uses

The intended use of the road safe phone case is as its name implies. To keep the roads and drivers safe, especially drivers that are easily distracted by their phones. The case restricts the driver's ability to access their cell-phone while driving, which will increase the safety of driving for themselves and others significantly. More specifically, the road safe case not only locks away the driver's phone, but their car keys as well. In order to access one item, the other must be locked in the case. Audio capabilities such as GPS or music can still be utilized while the phone is in the case; however, the screen will not be visible.

Studies have shown that compared to adults, teenage drivers are four times more likely to get into car crashes or near-crashes when talking or texting on a cell-phone, with approximately 21% of fatal teenage driving accidents resulting from cell-phone distractions (Edgar Snyder and Associates, 2016). As a result of these trends in distracted driving, the road safe case will primarily be used by teenagers. However, an AAA poll that showed while 94% of teen drivers acknowledge the dangers of texting and driving, 35% admitted to still doing it anyway (Edgar Snyder and Associates, 2016). This demonstrates that many teenagers would not impose phone restrictions on themselves. Thus, the case will be marketed to parents who have to the ability to oversee their children, and choose to enforce safer driving for them.

Distracted driving due to cell-phones is not only abundant in teens, but especially in drivers in age groups above 20 years-old as well (National Highway Traffic Safety Administration, 2012). Thus, the road safe case may also attract responsible drivers that choose to limit their distractions on their own, unlike a young teenager whose parents may buy the product for them. However, to use the product to its full potential, an additional individual should assist the driver by serving as the "parent" figure and holding the driver accountable for maintaining use of the case and not engaging in distracted driving.

1.6 Assumptions and Limitations

Assumptions:

- The case will operate off a battery as opposed to a car source.
- The case will only detect if an object placed inside is a phone and a key.
- The driver will only have one phone.
- The driver will be capable of accessing their phone in an emergency.
- The driver has a designated individual in which notifications can be sent.
- The cost to fabricate the case will be under $500.
- The case will be sold to other individuals.
- The case will fit in a car comfortably.

Limitations:

- The system will operate from a battery supply because the case will be portable.
- The phone case will only detect one phone at a time; thus, it cannot restrict other passengers in the car.
- The phone's features, such as GPS or music, will only be accessible through audio because visuals will be covered/restricted by the case.
- The case must be small and lightweight to avoid restricting passenger seating, to be easily portable, etc.
- The road safe case will function as a two-person system, so that if the driver uses the emergency access to open it, an emergency contact will be alerted.
- The project must be completed with a budget of $500.
- The end cost of the product should be relatively inexpensive because this product will be made available to other potential consumers.
- The project must be completed by the end of the year.

1.7 Expected End Product and Deliverables

The entire design of the road safe case will be completed by the end of April, possibly with a prototype as well so that some of the parts can be tested before constructing the end product in the fall. The capabilities of the case will continue to be tested and discussed between the team and the client throughout the year, so that the final, fully-functioning product can be produced by December.

The vision for this final product is the physical, portable case that easily fits in a car, and will store the car key and store or release the phone based on the circuitry built and programmed by the team to protect the user from distracted driving. This will require a locking unit powered by a motor and controlled by the Arduino, a GSM module to send emergency notifications, and possibly a printed circuit board for further capabilities. These components will be safely and neatly stored in the case within the case, creating the Road Safe Phone Case that can either be further improved with additional software applications or marketed as is to other parents or responsible drivers that wish to purchase the product.

1.8 Related Works / Literature Review

There is a product that was proposed in 2017 by Michael Maguire to create a "The Shellback Smartphone Safe". The idea was to create a case for the phone that does not lock, instead it can be zipped closed to keep drivers from accessing their phone while driving. However, if a driver wishes to access their phone, they can easily unzip the case and use it. Because the phone has been accessed while driving, the product will send a message to a designated person to inform them that the driver accessed their phone while driving. Due to lack of funding, this project never left the idea phase and was never marketed.

There are also phone applications that can be installed for minimal fees that will restricted a driver's access to the phone while driving at a certain speed. For example, an app called Drive Smart will allow users to direct incoming calls to voicemail, mute incoming texts and send an automatic response that he/she is currently unavailable (P, 2017). However, the biggest problem with an app such as this is that instead of avoiding people from using the phone, it tries to change certain functionalities of the phone such as muting the text and directing incoming calls without doing so in the most efficiency way, which is ultimately to prevent the driver from reaching their phone during driving. Therefore, the case became a more desirable potential solution for removing the distraction of dangerously using a phone while driving.

The other main function aside from restricting phone access through simply trust or incentive or through an app stored on a phone is the physical locking feature that provides a restrictive barrier. The road safe case project proposal resembles a safe; however, with two sides for storage and with conditions that must be met for locking and unlocking. Safes open when given a number combination on a lock or a PIN pad or with a key. This approach for locking the phone and key is insufficient because the user can choose to open the case while driving, which is the issue at hand. Traditional safes also typically have one large storage area rather than separated compartments because it is simply a storage area; thus, there is no help for object detection features that can be re-implemented into the product. A new design for an object recognition subsystem will need to be created for the project.

2. Proposed Approach

2.1 High-level Block Diagram of System

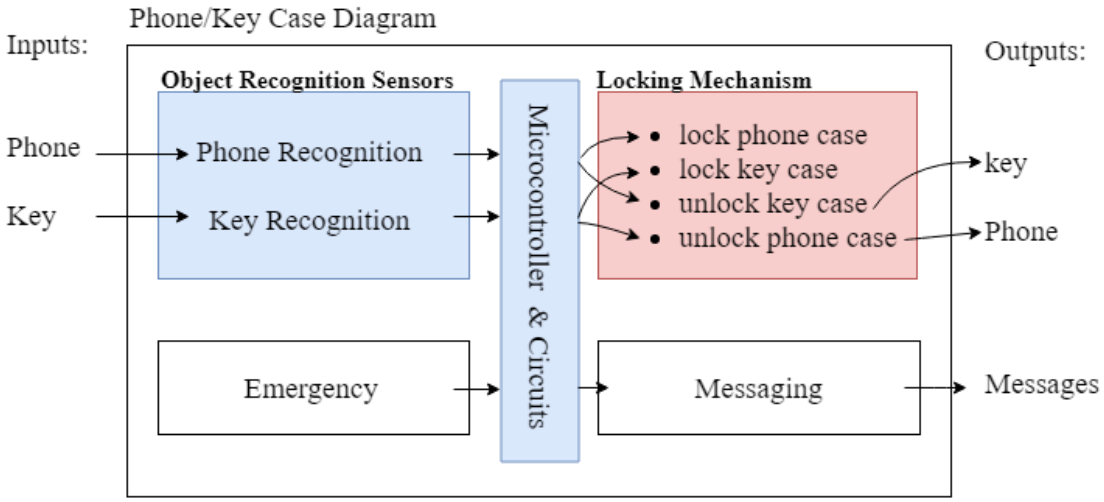

Figure 2: System Block Diagram

2.2 Functional Requirements

The potential consumer group are parents who have children that currently (or are learning to) drive. The road safe case needs to be restrictive on the cell-phone use while the user is driving with no exception. In case of an emergency, the phone case holder should be able to immediately access either the phone or key. To ensure normal, safe-driving operations, the case then needs to have some form of a "passcode" from a parent or designated person to reset the normal operations of the case or simply a method for sending a notification to that person to alert that an emergency has happened.

2.3 Constraints Considerations

The timeline for this project is within two school semesters, with a small possibility of the work being done over the summer because team members have other responsibilities that must be tended to during break. This is a relatively small amount of time to create a fully functioning project especially if unexpected events, such as a broken part or faulty design are discovered when the product is being constructed during the fall. As for the parts themselves, it can be difficult to find components that fulfill to perform the desired functionalities. Thus, compromises must be reached. Another constraint to searching for parts is cost as well, with a limit of $500 to spend on resources.

2.4 Technology Considerations

1. Lack of professional level of equipment to perform mechanical parts production.
2. Cell-phone recognition technology is hard to achieve because the product should not allow other people to use another device and make the case falsely believe that the detected object is the user's phone.
3. Sophisticated parts may be able to improve the functionality of certain components; however, more capabilities warrant a higher cost.

2.5 Technical Approach Considerations

For this project, the team's goal is to eliminate the fatal distraction from the cell phone usage while the user is driving and minimize the chance of a car accident. In order to achieve this goal, the team researched approaches other than what was originally proposed by the client, which was to build a physical case to lock away the phone. Some other options explored were making a software that can sense the moving speed of the vehicle and use that to determine whether the phone should be accessible or creating an app or some form of an interface with the vehicle to force the driver's phone to enter "Air Mode" during the drive. The disadvantage of this approach is that the software does not have firm control over cell phone usage, the user can delete or turn off the app easily, and could not discriminate if the user is a driver or passenger.

A further analysis of the software-based and hardware-based solutions are shown in the tables below. For hardware the team focused on the advantages and disadvantages of the case, which would be a new product, a physical case that is portable and more restrictive on the user. For software, an improvement on an existing app or creating interface with car to restrict users when they choose to was explored.

PROS	CONS
• Can't touch or look at the phone • Safer because a parent or designated person has more control over driver's phone usage • Easy emergency access • Has not been made before, first of its kind • Possibly more preferable by older generation or protective parents because this option is more restrictive and physical	• Physical case - needs to be carried at times and must have space in the car to accommodate it • More expensive to purchase • If another phone is in the car, driver could use friend's phone • Difficult to fully enforce this tactic on a driver • Infotainment and GPS capabilities are more limited because they can only be accessed through audio and speech

Table 1: Hardware Approach

PROS	CONS
• The product is already on the phone, so it is easier/more convenient to access • Ability to look at the navigation (also a drawback) • Easy emergency access • Cheaper to make and purchase • Blocks or replies to calls for the driver to let others know they are driving • Possibility for driving analysis or parental control/communication options	• Driver can look at and touch the phone at all times • Less control over usage because apps or plug-ins can easily be disabled ○ To undo 'safe-driving mode', user can tap to unset easily or if the app relies on vehicle speed, it may allow for traffic usage while driving • If another phone is in the car, driver could use friend's phone • Difficult to fully enforce this tactic on a driver

Table 2: Software Approach

The expertise of each team member as well as the compatibility of all components must be considered carefully to ensure the project can be completed within the timeline. Due to majority of team members being electrical engineers, the hardware approach will be taken. If time allows, software-based features that may compliment the road safe case will be explored by the team or recommended for further development after the initial product is done.

2.6 Testing Requirements Considerations

Testing requires that the mechanical linkage operates in a precise manner to have correct input and output signals to electrical components. The road safe case will need to operate in different cars and with different phones and keys. A variety of objects and environments must be accommodated for.

The criteria for each subsystem test of the project is provided below:

- For the locking mechanism testing, the team needs to ensure that the mechanical linkage operates in a precise manner to have correct input and output signals to electrical components.
- For the cell phone and key fob sensing testing, The team needs to ensure that the RFIDs are coded correctly and give precise input and out when the objects are placed into the box.
- For the cover open and close sensing testing, the team need to ensure that the mechanical components are precisely aligned with the electronic sensing devices and perform the accurate mechanical and electrical operation

- For emergency override system testing, the team needs to ensure that the electrical circuit has the correct design and bypass correct safety features.
- For the intrusion detection alert system, the team needs to ensure that the GMS module is compatible with the existing circuit and send out the alert message when the emergency takes place.

2.7 Security Considerations

All design drawings and instructions will be stored in the designated personal laptops with restrictive access, so to not leak the product design. Because the project will be heavily hardware based, security issues that arise with software applications need not be considered unless the team is able to pursue that approach.

2.8 Safety Considerations

The project may involve circuit soldering which introduces a risk of burns to users, and in worst cases, it is a potential fire hazard. The assembly of the road safe case itself may involve nails, screws, and bigger tools if deemed necessary later on, which must be handled with care to avoid injury to users as well. Thus, a two-person team principle is a requirement for all project designs to ensure safety.

User safety is also of utmost importance. Researching and adhering to engineering standards that pertain to the product that the team is developing will be followed to ensure their safety. Being confident in the team's knowledge and work efforts is essential as well to produce a strong, trustworthy product, which favors a hardware approach for the project. Another component that will help ensure safety is educating the user on the end-product, which will be accomplished by creating a manual at the end of the project timeline.

2.9 Possible Risks and Risk Management

This project design has limited funding support. The goal is to optimize the operational capability of the phone case to accomplish the desired functionalities with minimal parts expenses. For every step of the technical proposal, the team will attempt to borrow parts from an on-campus electronics store for testing the feasibility of the different approaches. Purchases will be decision-based, considering the testing results to avoid the unnecessary waste of resources.

Safety is also an essential aspect of risk management. The project involved a lot of hands-on mechanical work — activities like cutting, soldering, and installation. Wearing proper PPE (Personal Protective Equipment) is a requirement for all engineering design processes.

Time consumption is another issue for the senior design project. The project involves a lot of modern technologies and methods that are not covered by the course curriculum. The team needs to spend a tremendous amount of time to research, study and compare the different approaches to optimize the cost performance.

2.10 Project Proposed Milestones and Evaluation Criteria

This project design has limited funding support. The goal is to optimize the operational capability of the phone the months, the team will work on the major overarching tasks listed in the Statement of Work section. These tasks will be used in both the design portion of the project in the spring and the construction portion in the fall as the proposed project milestones.

By the end of April, the team should have a design for each component and potentially a rough prototype with the major functionalities. The evaluation criteria should be the interlocking operation, sensor performance, and parts mechanical performance. By the end of November, the team should have the end-product with full functionalities. The evaluation criteria should be the functionalities testing in real time situation.

2.11 Project Tracking Procedures

The team will rely on the Gantt Charts, which can be found in the Project Timeline section, and will also work to divide the whole project into different aspects for individual or subsets of the team to focus on. Each team member will rely on themselves and especially one another to enforce and strictly follow this time table. Also, by dividing the team into different working branches depending on individual member's own field of study, it will be easier to concentrate and accomplish small tasks that will build the project. The team leader will decide the due date for each individual component for further testing and development. Other external project trackers are the advisor and the client, who will be updated on the team's progress on a weekly basis.

3 Statement of Work

3.1 Task: Object Recognition Sensors

Objective: To successfully detect whether the object in the case is strictly a phone or a car key.

Approach: Using a charging port to detect the input and recognize the owner's phone. Another sensor can be used to verify the phone and key as well, such as a proximity sensor or a form of machine learning with a camera if that is affordable and compatible with other parts.

Expected Results: If the driver is to put in the wrong object to attempt to access the phone while they are driving, the case will not unlock because the object is incorrect.

3.2 Task: Locking Mechanism

Objective: To keep one side of the case sturdily locked at all times. Throughout this semester, the team has made a significant improvement on the locking mechanism. The new locking mechanism design saves a lot of power and pin usage for the Arduino board. The old design requires two circuits and two electrical bolt locks for each side of the case. The bolt lock does not have an active safety feature and can easily gain access by disconnecting the power source or breaking the lock coil. Also, electrical bolt lock needs to be energized continuously to maintain the locking condition, which consumes a lot of power.

Approach: The new locking mechanism design is to use a motor operating lock which is made of a servo motor and a gear rack. The operation of the motor lock based on the output of the object detection sensor. The control for the circuit will be coded using a microcontroller.

Expected Results: The motor operating lock only energizes when the status of the case changes, which saves a lot of power. Also, the motor operating lock has stronger safety feature than the bolt lock; even the motor is de-energized, the case can still maintain its locking condition.

3.3 Task: Emergency Access and Alert

Objective: To successfully resolve the situation when the driver encounters a car accident and needs to use the phone for seeking help. In this instance, the case should automatically open. The parent or designated individual should also be alerted that the user is in an emergency. Afterwards, the case should function normally again.

Approach: An emergency button will be placed on the case that will cause the circuit to override the circuit and open the locked side. The team is considering using a Global System for Mobile (GSM) communication module, which will work but is expensive. The search for an alternative alert approach is still under progress.

Expected Results: The case will always function normally unless in the case of an emergency, in which a designate person will be notified.

3.4 Task: Physical Case

Objective: To successfully make the physical case with pre-designed space to integrate the circuit components as well as the phone and car key. This includes making the case function for smart keys, which allows the driver to keep the key fob pocketed when unlocking, locking and starting the vehicle, meaning that the car can start as long as the key is anywhere inside the car. Working around this would require blocking the signal between the smart key and the vehicle.

Approach: Record measurements of circuit parts, locking tools, various phones and car keys, and other materials to design a case layout. Then use 3D software to create the layout of the case and a 3D-Printer to supply the materials and make the physical case. Aluminum or another metal is effective for canceling magnetic fields and blocking signals, so a material of this sort will line the inside of the key-holding portion of the case.

Expected Results: A solid and good-looking case with the space for circuits components that works for old and new vehicles.

3.5 Task: Testing Product

Objective: To make sure that all components work together after implementation.

Approach: The team will test individual components first to make to confirm they work separately. After combining all the components all together, then the final product will be tested as a whole and make sure all the functionalities are still functional and meet the requirements from the client.

Expected Results: To produce a fully functional and reliable road safe case which meets all the demands from the client.

4 Estimated Resources

Personnel effort requirements	Other resource requirements	Financial requirements
• 6-8 hours a week per team member work individually to find new technical approaches for current project issues. • Weekly meetings with the advisor and client to update the project status and optimize the functionalities of the project. • Work together on weekends to test and implement the new method.	• Potentially access to a 3D printer • Help from project advisor or additional professors with other specialities with project components • A parts supplier to order the project components from the outside of the school, if not supplied by the Electronics Technology Group	• Funds to purchase circuit components: wiring, sensors, microcontroller, locking device, communication device ≈ $40 • Funds to purchase 3D printing materials for prototype ≈ $5 For end-product ≈ $20 • Operation fee for using 3D Printer and soldering device ≈ $5

Table 3: Estimated Resources

5 Project Timeline

5.1 Spring Semester

The project team was assembled at the end of January, and February has marked the start of the design portion of the project. The initial schedule for the major research and design tasks are represent in the Spring 2019 Gantt Chart below.

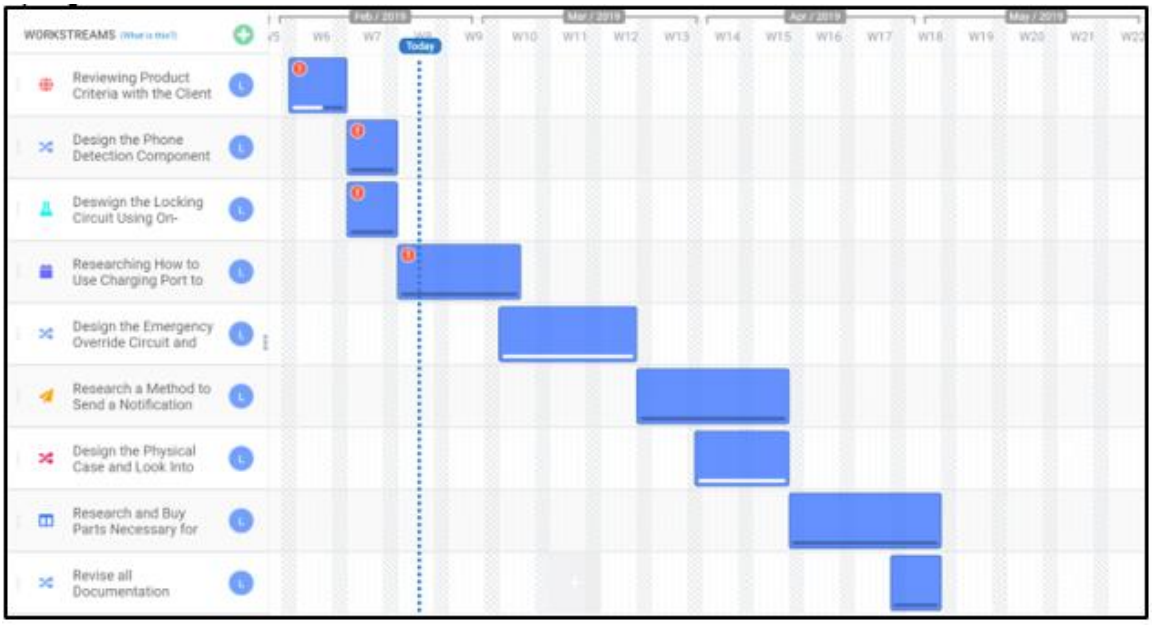

Figure 3: Spring 2019 Gantt Chart

An explanation of the tasks in chronological order:

1. Review product criteria with the client to ensure the design meets their needs.
2. Design and research object proximity or recognition sensors for the case.
3. Design the locking circuit and test using on-campus resources.
4. Research how to use charging port to detect the phone belongs to the driver.
5. Design the emergency override circuit and reset for normal functioning component.
6. Research a method to send a notification from the case to alert emergency access.
7. Design the physical case and look into materials to build it.
8. Determine the most ideal parts that are essential for the circuits.
9. Revise all documentation needed for the project construction during the fall.

5.2 Fall Semester

After summer break, the project will resume with the construction portion. The team's initial schedule for building each of the main components are represented in the Fall 2019 Gantt Chart below.

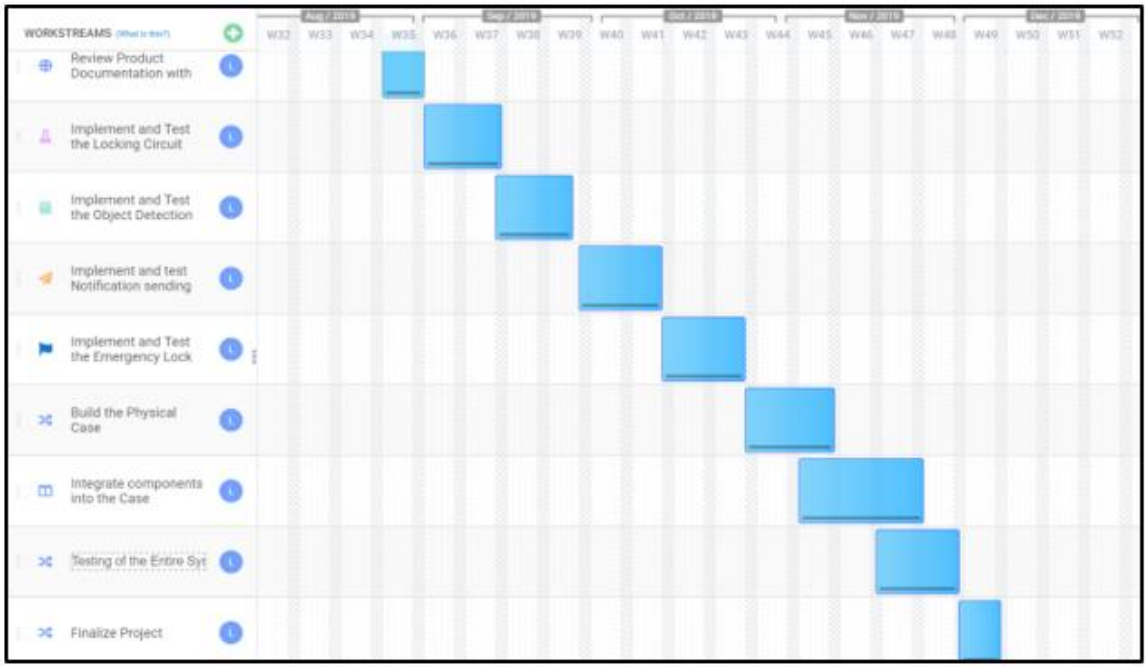

Figure 4: Fall 2019 Gantt Chart

An explanation of the tasks in chronological order:

1. Review product documentation with client and team as a refresher.
2. Implement and test the locking circuit and verify it works with object detection.
3. Implement, test, and integrate the emergency override circuit into the system.
4. Implement and test the emergency notification sending and reset.
5. Verify that all components work together.
6. Build the physical case to fit all parts.
7. Integration of the circuit components into the physical case.
8. Testing of the all the components as a whole.
9. Finalize documentation and the physical project itself.

6 Conclusion

6.1 Summary

The undeniable fact is that cell-phone usage while driving is highly dangerous for both the driver and other individuals on the road. A lot of worry surrounds the safety of young drivers, especially as they have been shown to have the highest rates of phone usage while driving as compared to individuals 25-years-old and above. To increase safety on the road, the amount of distractions must decrease which can be achieved by removing the temptation of a phone through the Road Safe Phone Case. By a locking mechanism that will store either the driver's car keys or cell-phone at all times along with sensors to detect the correct objects, access to distractions will be restricted. The case will also accommodate for emergency situations and allow important phone functionalities such as GPS and Bluetooth to still be utilized through audio. With team members' engineering knowledge, assistance from an advisor, and adherence to project plans and timeline, the road safe case will be successfully designed, constructed, and tested within the year. Not only will the case help parents feel relief while their children are out on the road by themselves or give responsible drivers an ease of mind, but it will also save lives.

6.2 References

Arduino Uno Rev3. (2019). Arduino. Retrieved from https://store.arduino.cc/usa/arduino-uno-rev3

Centers for Disease Control and Prevention. (2017). Distracted Driving. Retrieved from https://www.cdc.gov/motorvehiclesafety/distracted_driving/index.html

Edgar Snyder and Associates. (2016). Texting and driving statistics. Retrieved from https://www.edgarsnyder.com/car-accident/cause-of-accident/cell-phone/cell-phone-statistics.html

Maguire, M. (2017). Help prevent 3,000 fatal car accidents in 2017!. Retrieved from https://www.indiegogo.com/projects/help-prevent-3-000-fatal-car-accidents-in-2017#/

National Highway Traffic Safety Administration. (2012). Young drivers report the highest level of phone involvement in crash or near-crash incidences. Retrieved from https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/811611-youngdriversreport_highestlevel_phoneinvolvement.pdf

P, E. (2017). 5 of the best apps to encourage safer driving. Retrieved from https://fixautousa.com/blog/5-apps-for-safer-driving/