**Hot Car Emergency: Prototype I and Customer Feedback**

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**Abstract**

This document lists the overall prototyping objectives of the project. It details the first prototype’s schematics and its testing process. The main goals for this prototype were to test for product sizing and for structural integrity using certain materials. Following testing and analysis, we developed test plans and objectives for the next prototype that will be constructed for the 11th of November. The project task plan is also appended.

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# Introduction

The previous document provided a detailed drawing of the proposed system and a comprehensive bill of materials. With the final construction deadline quickly approaching, it is now time to verify those design concepts. In order to screen the design for errors, a series of prototypes will be constructed. Each prototype will satisfy a collection of objectives, which will be constructed with respect to standards, questions, and concerns surrounding the final design.

# Prototyping Objectives

“Why” Objectives:

1. Determine physical dimensions of the product to communicate to the client
2. Ensure product is functional in heat intensive environments to minimize risk of heat related failure
3. Determine basic installation concept to create opportunities for learning and improvement
4. Establish functionality of critical systems to create a foundation for future prototypes

“What” Objectives:

1. Create a rough physical prototype that is comprehensive in order to show all physical dimensions and shape of product
2. Stress test the product in heat intensive conditions to determine failure points and durability
3. Test placement of product in various locations in the vehicle to determine optimal placement and/or mounting strategies
4. Create basic circuitry using free online software that models the most critical systems of motion detection, temperature detection, and alarm sounding.

“When” Objectives:

1. Finalise the product dimensions and laser cut the external casing by November 7.
2. Receive all necessary components for the second physical prototype by November 8.
3. Test each individual module to ensure their functionality and quality by November 8.
4. Compile the individual circuits for each component into one working circuit and test its functionality by November 9.
5. Begin creation of the mobile app that will incorporate the product’s bluetooth functionality by November 10.

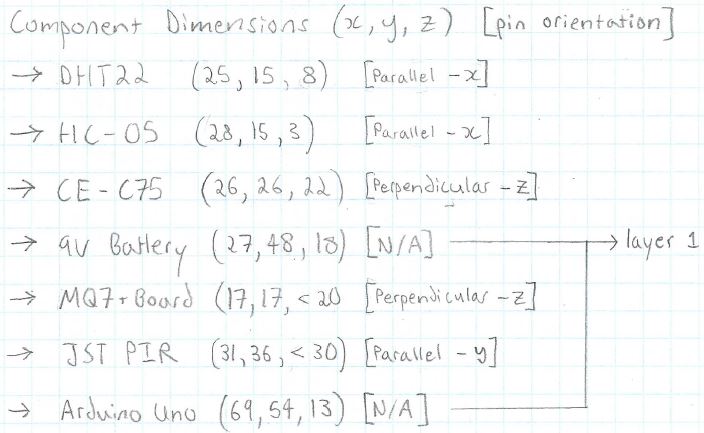
# Prototype I

The first physical model is a proof of concept. Due to material constraints, it is constructed from cardboard (shell), low density polyethylene (modules) and hot glue (fastenings). This prototype is designed with an eye towards the following objectives:

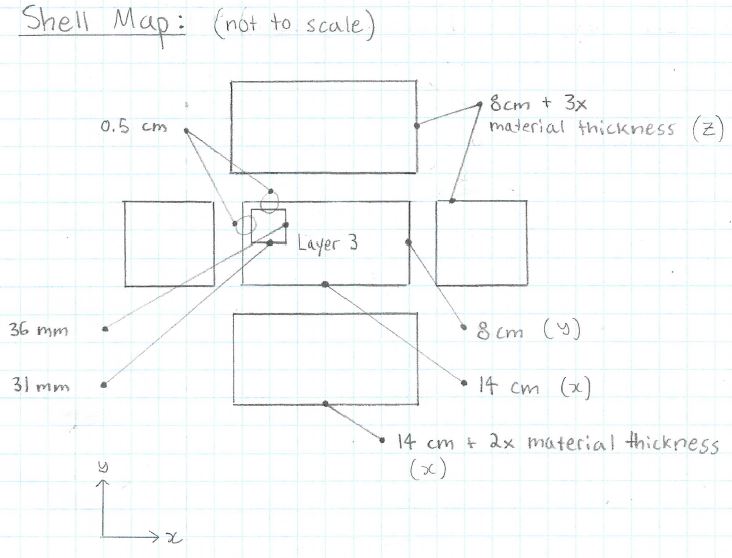
1. Determine suitable dimensions for a shell that can house the recently-revised list of components
2. Determine if hot glue is a viable option for securing modules in the final design
3. Observe the form of the design in real-space and find a suitable mounting position for the device inside a standard vehicle.

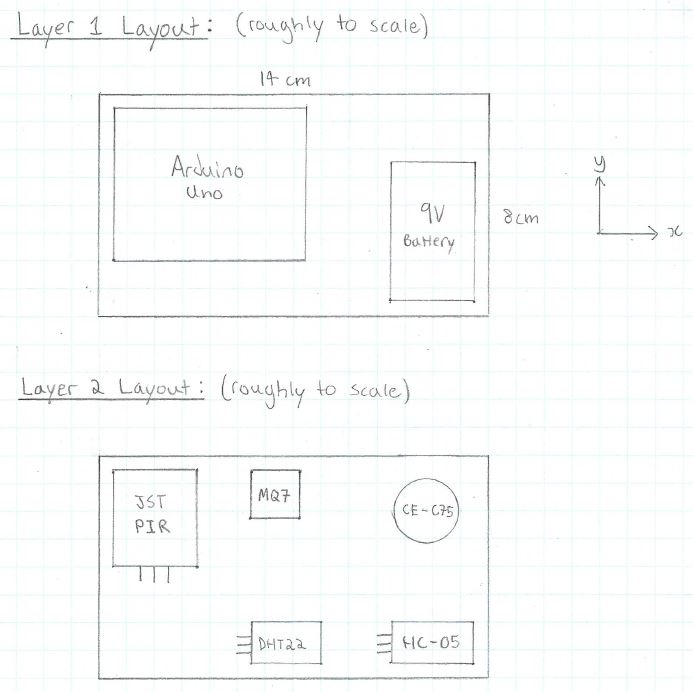
## Components

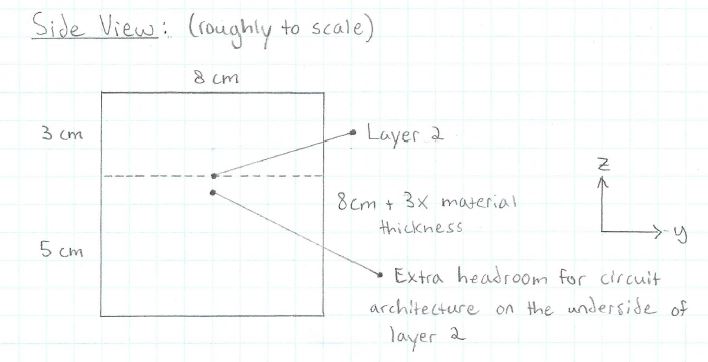
The revised bill of materials affords the following components. Their dimensions (relative to placement inside the device) are listed in millimeters (mm), rounded up or generously overestimated to ensure that no modules in the final design will be larger than their current mock-ups.



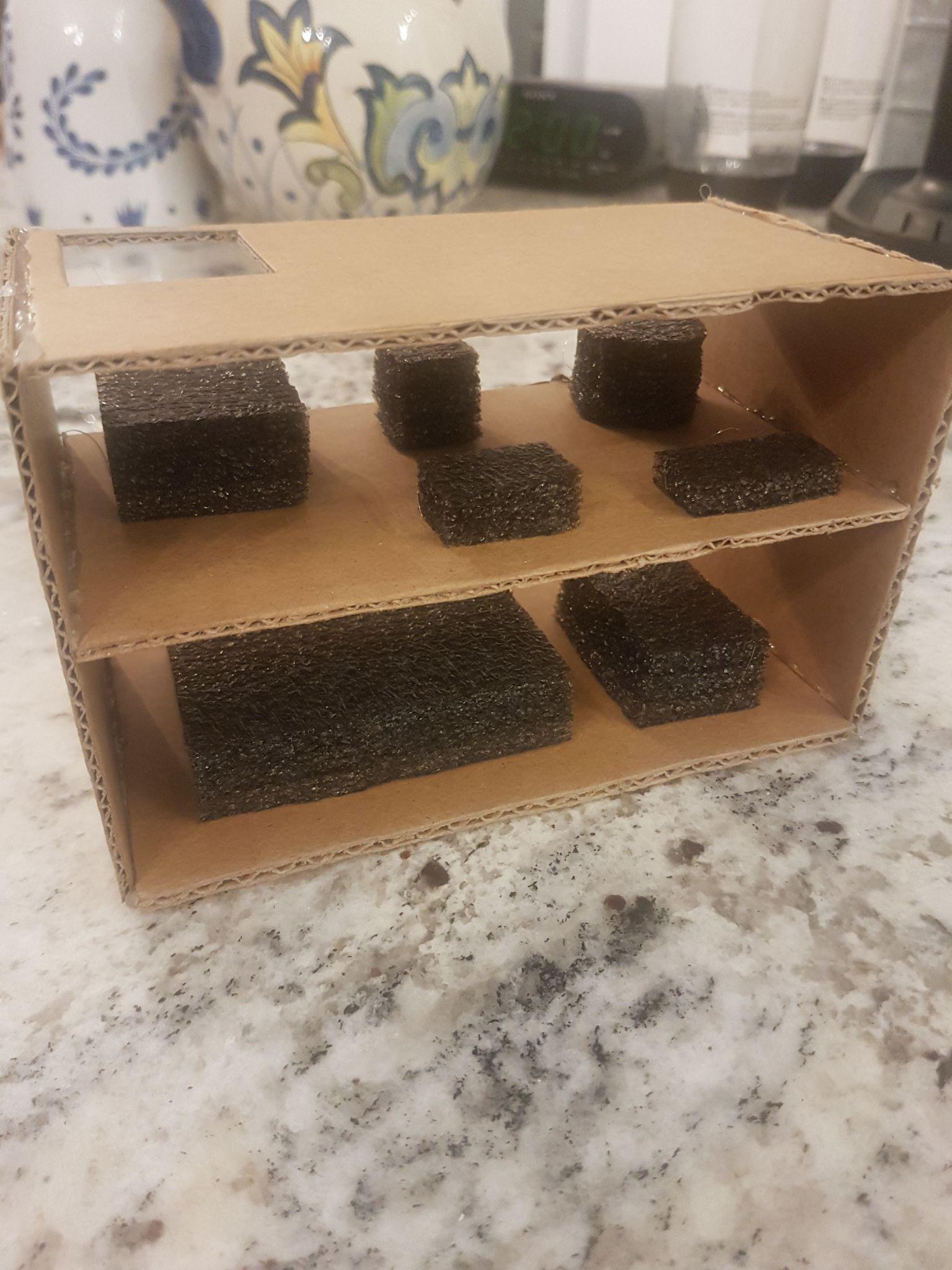
## Schematics







### Model





## Testing

1. As evidenced by the photos above, the current dimensions are more than adequate to house all necessary components. In fact, the distance between layer 2 and layer 3 (the top of the device) is probably too large. Future prototypes will reduce this distance to make the device more compact.
2. A temperature test was performed on the physical model. Video documentation can be found at the hyperlinks below. Notably, after approximately 28 minutes at 75 degrees celsius, the hot glue failed to hold the model together. This result will be considered carefully in the construction of the final prototype.
   1. [Start of Test](https://drive.google.com/file/d/1V2ILGeRaGzrckwCguvCSFkJ5vcqz60Ai/view?usp=sharing)
   2. [End of Test](https://drive.google.com/file/d/1UMHRTGRKg8oLLJlQnZQqYSDkd7wQPxZg/view?usp=sharing)
3. General observation of the device inside real vehicles revealed that it must be possible for the device to be mounted on gently curved surfaces. If suction cups are used to secure the final prototype to the vehicle, adjustable orientation is preferable.

# Analysis and Feedback

The intended purpose of the product is to notify users when the temperatures and carbon monoxide levels in a vehicle reach unsafe conditions. Thus, the purpose of the first prototype is to test for both its dimensions and for its stability under high temperatures.

Based on the cardboard prototype, which is built to scale, the preliminary dimensions were adequate for encapsulating and protecting the necessary components. However, it was found that the dimensions could be reduced to fit a slimmer form factor, which would allow it to fit more comfortably in any vehicle, regardless of make or model. And so, these initial dimensions will be tweaked further for the second prototype’s casing.

The cardboard prototype also underwent temperature tests to test for structural stability. This is to see how the product would fare if we were to use hot glue for the final product. The hot glue was adequate for holding the case together until the temperature reached 75°C. Despite this, it may still be feasible to use hot glue for the final product as the notification system should sound off much earlier than this point in a real scenario. However, we will still consider the use of other, more heat-resilient materials for the final product.

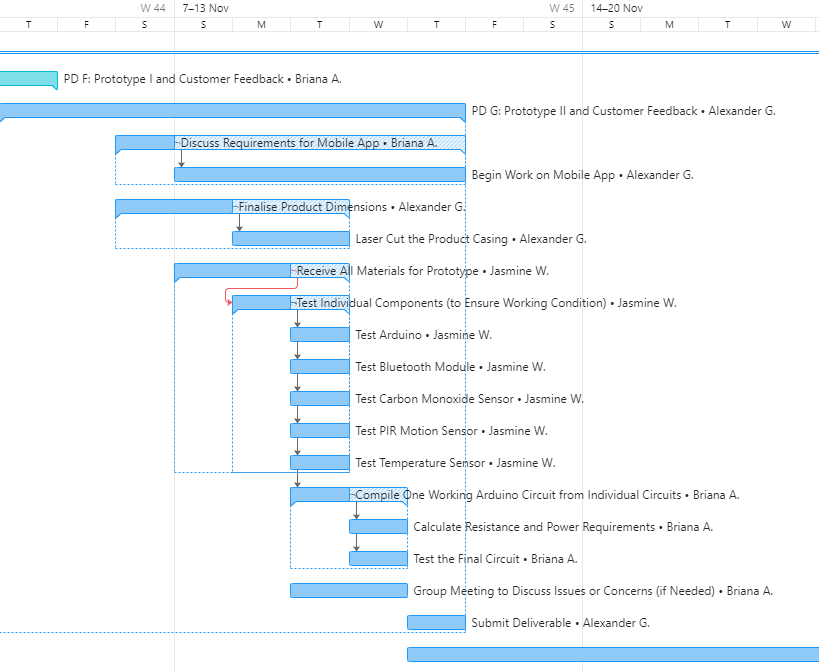
# Test Plan for Prototype II

| Test  ID | Test Objective  (Why) | Description of Prototype used and of  Basic Test Method  (What) | Description of  Results to be  Recorded and  how these results  will be used  (How) | Estimated Test  duration and  planned start  date  (When) |
| --- | --- | --- | --- | --- |
| 1 | Communicate expected design of bluetooth module circuitry | Create a virtual circuit that includes bluetooth communication | Effectiveness of bluetooth connection to create a foundation for future prototypes. | Test duration: 1 minute, planned start tuesday November 9 |
| 2 | Communicate expected design of mobile app | Create a basic mobile app using free software | Mobile app functionality to gather information regarding feasibility of applicable features | Test duration: 1 minute, planned start tuesday November 9 |
| 3 | Reduce uncertainty surrounding internal product components | Physical Arduino circuit and applicable code | Effectiveness of Arduino circuit | Test duration: 1 minute, planned start Monday November 8 |
| 4 | Reduce uncertainty surrounding product dimensions | Physical product casing using laser cutting techniques | Product dimensions, will be used to evaluate car mounting options | Test duration: 5 minutes, planned start Monday November 8 |

Stopping criteria for all tests: test yields desired specifications or fails to reach the desired functionality by Thursday, November 11.

# Project Task Plan

For the second prototype that is due on Thursday, November 11, we have planned to make it a semi-functional model with regards to the environmental sensors and audible buzzer. We have also scheduled a meeting to discuss the mobile app that we hope to complete for the third prototype. The second prototype, therefore, will focus primarily on the Arduino’s circuitry and its electrical components. It will also involve work on the mobile app that was requested by the client. A Gantt chart of the upcoming deliverable and prototyping plan is provided on the next page:



The next client meeting is scheduled for Wednesday, November 10. As such, these project tasks and subtasks are subject to change following client feedback and prototype testing.