Project Deliverable F: Prototype 1

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Introduction

Preceding deliverables have allowed us to grasp the client's needs, to come up with appropriate design criteria for our project, and to combine individual designs into a complete final concept, which took into account target specifications, constraints and project limitations. This deliverable first documents the development of Prototype I, more precisely its prototyping test plan, the process itself, the testing stage and how we plan on improving the product based on the client's input, which will help us conceive a better second prototype. As the prototype will have physical components and will have to be operational inside a car, testing will have to be executed and carefully documented by a single team member; results will then be analyzed by the entirety of the team. Additionally, this deliverable contains our second prototyping test plan, which will be crucial for the creation of Prototype II. Both our first and second prototype will help us understand how we can elevate our design and functionality, configurability or aesthetic changes we can bring to optimize our final product's practicality.

Prototyping Test Plan I

Note: since many of our components are scheduled to ship in about two weeks (including all three sensors, the GSM shield, the current detector and the buzzer), so physical testing is limited for prototype I.

Test ID	**Test Objective (Why)** Lecture 11 Slide 17	**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	Performance, communication, learning	A cardboard version of the sensor module with similar anticipated volume and containing the Arduino and breadboard will be attached to a car's driver seat	Sensor module size and shape (we will try to determine more precisely if the anticipated dimensions are too high and approximately if the module is correctly	20 minutes, 2021/11/04 (afternoon)

		using velcro straps, in the configuration described in the final design.	oriented to allow the PIR sensor to detect movement in an acceptable range) and client feedback (will be taken to confirm the satisfaction of the global exterior setup of the design).	
2	Learning	Sketch and simulation for the PIR sensor, temperature sensor and buzzer interaction.	Determine if the sketch is adequate, the system functions fluently, and the process matches the identified needs. We will show the system simulation to the client, and get his feedback.	5-10 minutes 2021/11/04

Prototype I

The first prototype was a basic mockup of each component of the device. It first consisted of a cardboard shell to simulate the size of the casing. This shell was then filled with the main components of the device to gauge whether or not the dimensions needed to be changed. The second component of the prototype was the electrical circuit. This component consisted of the available sensors and output devices wired together to form a rough version of the final wiring layout. This part was made to check the function of the sensors and output devices. The third and final component of the prototype was the code. The code made was to test to see if the wiring would work in a simulated environment. This prototype was made to be basic and help analyze the fundamentals of this project to correct major design aspects if needed.

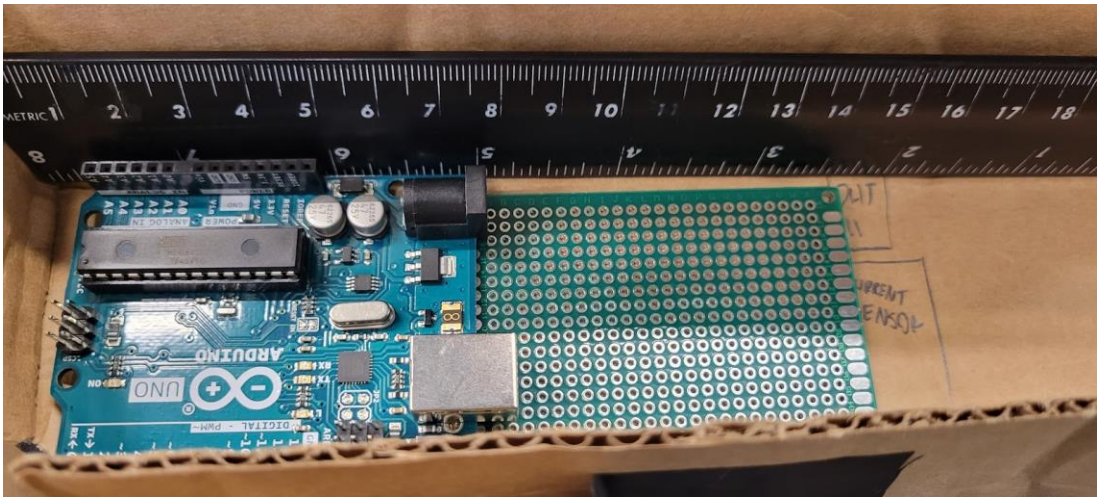
Analysis

In our first prototype, we were able to create very basic characteristics for our product. These preliminary actions are critical to ensuring that we can add to what we already have rather than having to start over each time.

The simplest task for our product was to figure out the basic dimensions, estimation of the weight of the product, the inner electrical layout of the product and the wiring of the Arduino. We used cardboard and used it as a 3D model for our casing to see how the electrical components would fit in the actual casing and to finalize our dimensions. The dimensions that were the most efficient for the casing to hold the components and be user-friendly in terms of size and weight were found to be: 210 mm x 45 mm x 70 mm. We also needed to ensure the straps holding our product to the seat headrest could hold the weight. We summed up the weight of the components and casing, and compared this to the recommended weight for the straps. In doing so, we were able to confirm that the straps would be able to firmly anchor our product. Using our cardboard 3D model, we were also able to layout the main inner electrical components of our product to ensure they fit and had the room needed to fulfil their respective duties. The Arduino was also wired with the sensors and buzzer to ensure we had the correct wiring outlay for all sensors to be working.

However, what has been more complex to figure out is the coding for the Arduino to incorporate all of our features: sensors, SMS, calling, buzzer, etc. Although we did not incorporate this into the first prototype, planning it out for the next one was done. We need to focus more attention on the software component of our product. Seeing that creating the casing and wiring the Arduino is very simple, we now know what will require more of our time. With this knowledge, we will schedule more time for the software aspect of our product. Coding in one document will let the team plan how to code all the features and create their interconnecting functionalities by using what we have learned. This first prototype also helped us see if there were any ideas, we needed to simplify even more to incorporate into the Arduino code.

Figure 1: Inner layout of electrical components in product casing



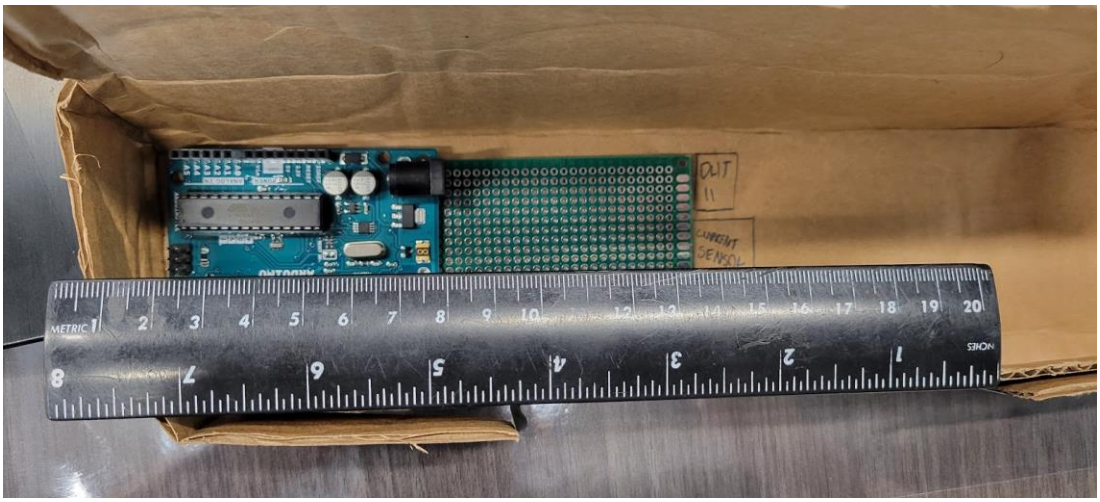


Figure 2: Inner layout of electrical components in product casing (intended length)

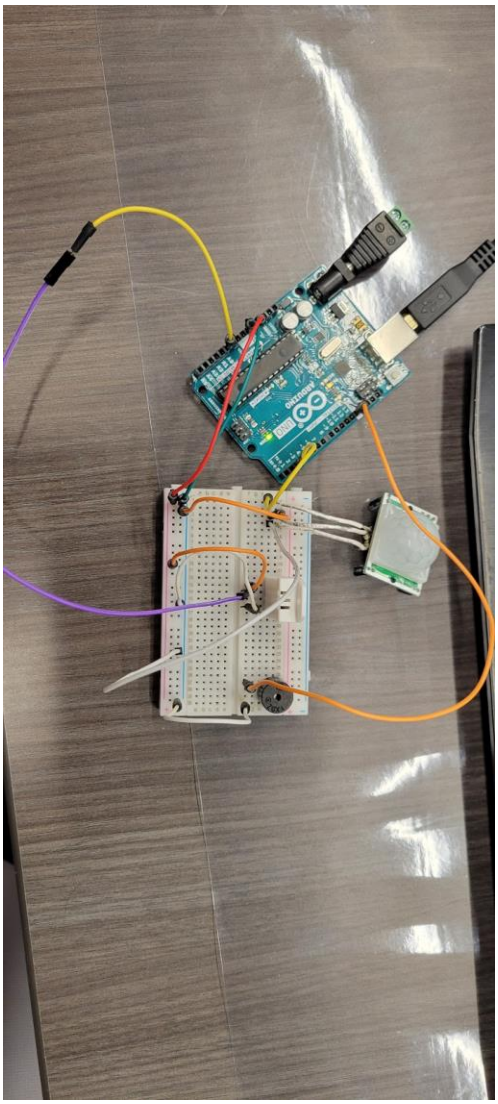


Figure 3: Wiring of Arduino with sensors and buzzer to be placed in casing

Prototype II Test Plan

Test ID	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	A wiring prototype will be made from the arduino and all available components.	The sensors will be tested using multiple test codes made to check the output values of the sensors.	10/11/21 Afternoon 30-40 min

	This will be tested for sensor functionality. An LED will be used as an indicator of a positive test result.	Sensors must be accurately outputting the correct values when tested by changing the environment.	
2	The structural prototype made from 3D printed acrylic will be test-fit into a car with the fastening system.	The device will be mounted to the rear headrest using velcro straps. The fit will be measured using metric length measuring devices (rulers, measuring tapes, ect.) The stability will also be observed.	10/11/21 Afternoon 5-10min
3	The structural prototype will be tested with its final fit. That being the devices inside and the fastening of the case using the bolts	The fit will be tested using measuring devices and exerting forces manually on different parts of the device.	10/11/21 Afternoon 5-10min
4	The circuitry will be checked for proper voltage, and amperage.	A multimeter will be used to test the circuit for abnormalities in the electricity to determine if function will be inhibited.	10/11/21 Afternoon 5-10min

Final Design Feedback and Related Modifications

Our second client meeting revealed much-needed information about the functionality of our product and allowed us to reevaluate our final design. Globally, the client seemed satisfied by our chosen design concept, though he observed inadequacies with our alert and power system. The prior was not triggered early enough and did not show the potential to sufficiently attract

the user's attention, as the client deemed too poor our initial idea of sending frequent SMS messages to alert the user when dangerous temperatures or carbon monoxide levels were detected along with movement in the back of the car. In other words, the alert system had to be instantaneous and truly unavoidable. To correct this, he asked us to find a way to detect when the doors locked and to immediately alert the user while he or she is still in the vicinity of the vehicle, as well as providing more than SMS alerts if the user did not hear or dismissed the initial warning. The client also insisted on implementing a passerby alert feature, as we had not found a practical way to install one just yet. Finally, our final design included a rechargeable battery module which would have to be recharged by the user at a rate which was yet to be determined. The client pointed out that the user could not be relied upon to perform such a task regularly, as the product's targeted clientele is constituted of highly busy parents or caregivers. Globally, the client asked for the system to accomplish two actions, that is to immediately alert the user, specifically when the doors locked, and to continue the alerting process remotely if the user inadvertently ignored the initial alert.

Consequently, considerable changes were implemented to our design. First, to solve the issues raised about our system's lack of instantaneity and low level of alert, we added a buzzer inside the device's sensor module, and using a current detector linked to the car's USB port and the PIR sensor, the buzzer will be activated to alert the driver as soon as the car is turned off and movement is detected in the backseat. An SMS will also instantly be sent to all phone numbers the client will have configured while ordering the device online. The halt function will be kept for the user or friends/family to be able to stop the process and ensure the child is safe. If no one initially responds—nor the user, nor friends/family (if applicable) notice any of the preliminary alerts—an automated phone call is directed, as well as more successive SMS alerts. Second, to alert the passerby, we will use bright LEDs, which we will latch onto the backseat window's frame. Passersby whose attention will have been drawn will then read an informative sticker located under this same window. This sticker would simply ask the passerby to call local authorities if he or she saw a child or pet alone in the car. Lastly, to ensure the system's power source does not require any attention from the user, we decided to use a 9V lithium battery, which is long lasting and does not require recharging.

Changes made to our device are reflected in the chart below.

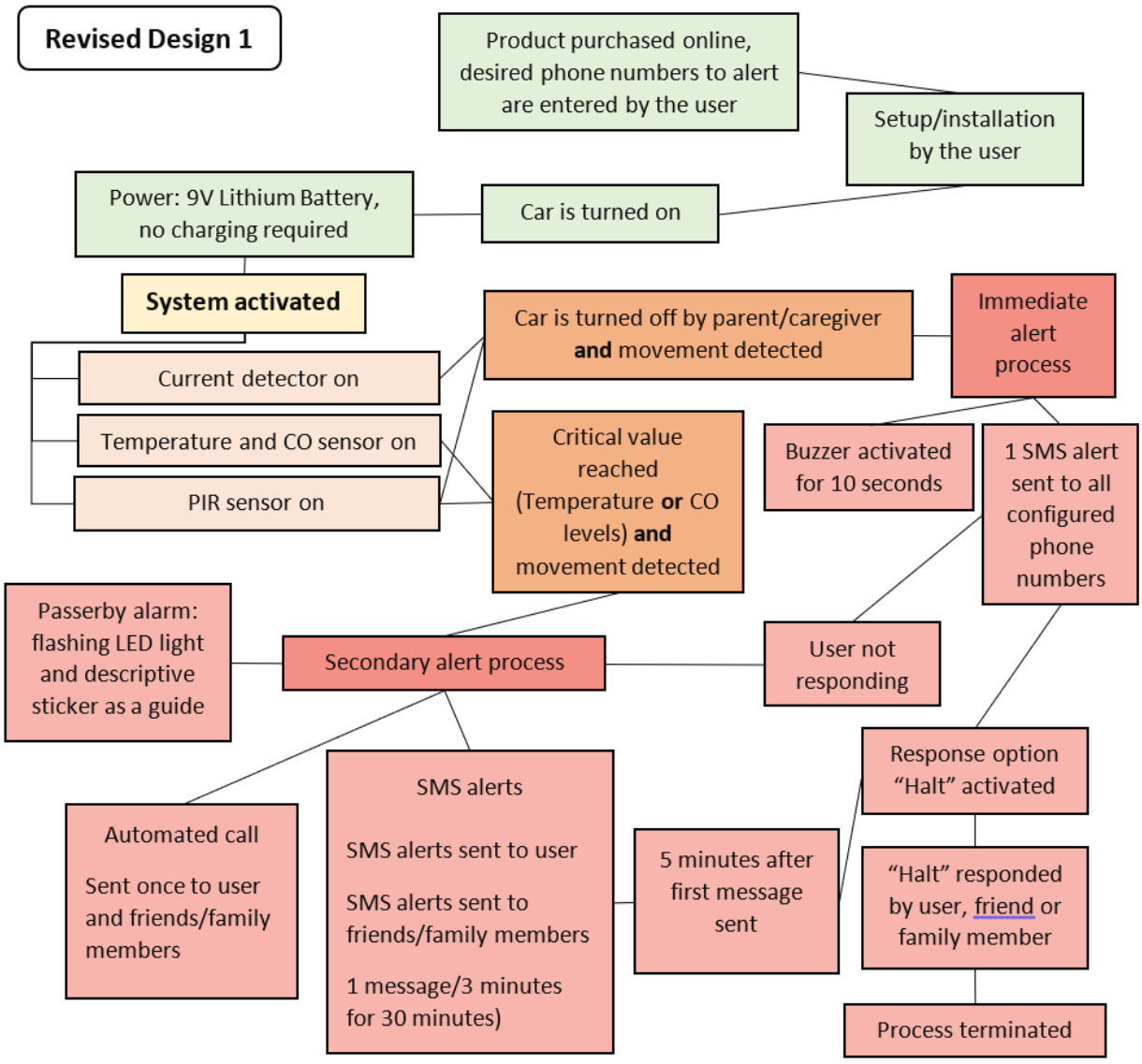


Figure 4: Revised Design Flowchart

Conclusion

In conclusion, this deliverable allowed us to consider any changes needed to be made after receiving feedback from the client meeting 2. Using the feedback, we developed a prototype test plan that will test the wiring of the components to the Arduino, the structural aspect of casing and mounting the device and finally ensuring the entire circuit functions properly with the correct electricity. Additionally, some modifications were implemented in this prototype, where the low level of alert was enhanced by adding the buzzer internally, an SMS will be sent to all the cell numbers the user will have configured online, along with the installation of LED strip lights to actively alert the passerby in cases of complications to the child/pet and lastly the device will not require the user to recharge the 9V battery constantly. Furthermore, our first prototype is ready for client feedback on the implemented modifications and fixes to our subsystems. Moving onto

the next deliverable, the focus will be towards developing and testing the coding for all the components along with making changes based off the next client meeting.