Project Deliverable D: Conceptual Design

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October 17th, 2021

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1. Introduction

In Deliverable C, we came up with and organized various design criteria for our product based primarily on client needs. We also established a list of constraints and requirements using these criteria and findings from technical benchmarking. In the present document, we will each create individual conceptual designs based on the previously determined criteria. These designs will subsequently be combined and refined to form three global project concepts, one of which will be deemed the most optimal for the team using a well-defined grading scale.

2. Individual Concepts

2.1 Aidan

2.1.1 Movement detection

2.1.1.1 Movement detection can be done using a PIR motion sensor that is compatible with microcontrollers and computers like an Arduino and Raspberry Pi.

2.1.2 Cost of material

2.1.2.1 The cost of material will be mostly made up of technology rather than any structure. This means that since aesthetics are not a high priority a majority of the cost will be based on prices of sensors, output devices, and a central unit. To optimize the cost, we must compare prices from physical locations and online suppliers (including shipping). Usually having the items shipped from suppliers would be cheaper.

2.1.3 Central control

2.1.3.1 Using a microcontroller limits the networking functionality of the device, therefore a computer would be a better option in this case. A raspberry pi would be an optimal choice as it is low cost, compatible with many sensors and can be set up to send SMS messages as well as connect to the internet. If only an internet connection is needed, then an Arduino would be better due to the reduced complexity and price.

2.2 Hammad

2.2.1 Temperature Detection

2.2.1.1 A temperature sensor will be used to detect temperature levels and notify the guardian when the temperature is at a point where it is dangerous to the child/pet who has been left in the car.

2.2.1.2 The KY-013 analog temperature sensor module is the primary option for our project as of now, which can detect temperatures between -55 to 125 degrees Celsius with an accuracy of plus/minus 0.5 degrees Celsius. It is compatible with Arduino and raspberry pi. Another sensor that can be used is a DHT11 sensor, this sensor measures temperature and humidity.

2.2.2 Gas Detection

2.2.2.1 A sensor will be used to detect carbon monoxide levels when they reach 100 ppm and are dangerous to the child/pet. Our primary option is CARBON MONOXIDE SENSOR - MQ-7, which is compatible with the Arduino. The sensor is easy-to-use and can detect from 20 - 2000 ppm.

2.2.3 Phone Application

2.2.3.1 Notification System

The phone application system will be connected to the temperature and gas sensors in order to receive the desired values and notify the guardian when they reach a point where they are dangerous to the child/pet in the car. When temperature values are received below 10℃ and higher than 26℃, or a carbon monoxide reading greater than 100 ppm, the application will send a SMS warning alert to the user with a screen pop up as well.

2.2.3.2 User interface

The interface will be designed to be direct so the user knows all the functionality. It will include the temperature and gas level measurements, the button to deactivate the alarm and a countdown of when notifications will be sent and a call will be made if the alarm is not deactivated manually.

2.2.3.3 Connection to Other Systems (Motion, Gas and Temperature)

The application will be receiving information from all the sensors in order to know when to activate the alarm system and send push notifications to the guardians. The alarm system will activate within the application when motion is detected of a child/pet in a locked car.

2.3 Laurent

2.3.1 Sound Alarm

2.3.1.1 Alerts the client via the app when conditions inside the car (temperature and gas levels) reach a critical value. Produces a consistent "alarm-clock" type sound until disabled. It is important for the chosen tone not to be confused with other common public area alarms, such as a fire alarm.

2.3.2 GPS System

2.3.2.1 Tracks the location of the car, to be transmitted to the family member or friend contacted if the caregiver doesn't respond to the alarm. This location can then be used by local authorities (after they are contacted by the friend/family member) to rescue the child.

2.3.3 Connectivity

2.3.3.1 Give the user the choice to connect the system either to the USB port or the cigarette lighter of the car by providing a 2-in-1 cable. Use of this cable would be explained in the user manual.

2.4 Shahid

2.4.1 Digital communication

2.4.1.1 The user will receive push notifications through the mobile application with warning text messages. These could be: “WARNING! DANGEROUS CONDITIONS HAVE BEEN DETECTED WITHIN YOU OR YOUR FRIEND OR FAMILY MEMBER’S VEHICLE! PLEASE TAKE IMMEDIATE ACTION!”

2.4.2 Car compatibility

2.4.2.1 To ensure our device will be compatible with all types of vehicles, we could install it on the headliner using Velcro on most types of headliners in a car. The electrical components will also have to be compatible with the components of the vehicle, so USB connections would be an option for relatively old to new cars.

2.4.3 Sound detection to certain decibels

2.4.3.1 In addition to temperature/humidity, gas and motion detection, to improve the accuracy of the child/pet presence detection, our device would detect a change in sound that is set to a certain decibel level to pick up signals of any crying sounds from the child/pet inside the vehicle. This component of the device would be connected to the alarm system on the app.

2.5 Yassir

2.5.1 Durability

2.5.1.1 Using reliable materials and components that could resist extreme temperatures and enable the product to function in the long term. This is especially important for busy families with many children.

2.5.2 Aesthetics of the design

2.5.2.1 Using shapes, colours, size, and add-ons to make the device aesthetically pleasing and as compact as possible with all its components without interfering with the functionality. The ideal aesthetic would be for the product to be as hidden as possible, in order not to attract the pet or baby’s attention (as he/she could damage it) and not to cause any irregularities in the car’s internal design.

2.5.3 Mounting the system on the headliner

2.5.3.1 Using Velcro material would be a simple and cost-effective option to mount the sensors to the car’s headliner, which would allow an optimal detected area and make this area easier to define in the computer system.

3. Global Concepts

3.1 Global Concept 1

To be set up by the user, the computer must first be connected to a monitor and keyboard for input of one or more phone numbers. The instructions to do so will be in a pamphlet that comes with the product.

This device will be made from multiple sensors, a control unit, and an alarm. The sensors and the control unit will be held in a plastic structure. More precisely, polyetherimide (PEI) could be used as it has high temperature resistance (i.e. a high melting point) and is low-cost. This structure will have openings for the sensors and clips on the back to mount to the back of a headrest.

To set up the product the user will be instructed in how to install the device on the back of one of the front seat headrests. This will be done using a paper instruction pamphlet. The device is then to be connected to a power source via usb or cigarette lighter connection so that the battery is fully charged. While the car is off, the system battery would run on the charge it acquired while the car was on. Wires would be long enough to run down the seat and connect to the desired port without obstructing movement.

Once in use the device will monitor the levels of carbon monoxide, movement using a motion sensor, and temperature/humidity. The device will have set values for each detected variable. These variables would be (Min temp: 10℃, Max temp: 26℃, Max CO levels: 100ppm). If the readings do not deviate from the set safe levels, nothing will happen. If they do and movement is detected inside of the vehicle then the device will start the alert process.

Once the alert process begins, the device will start an exterior alarm, which would be a voice recording (targeted to be in english only), to notify peoples near the vehicle. At the same time it will send an SMS message to the user and any other set numbers to notify them about the dangerous conditions within the vehicle. The text of the message will read as follows, “WARNING! DANGEROUS CONDITIONS HAVE BEEN DETECTED WITHIN YOUR OR YOUR FRIEND OR FAMILY MEMBER’S VEHICLE! PLEASE TAKE IMMEDIATE ACTION!”. This will repeat 10 times over 30 minutes. This system can be stopped after 5 minutes by the user responding with the text “Halt”. This instruction will be present in the paper pamphlet. This product would have then done its job and begun its regular function.

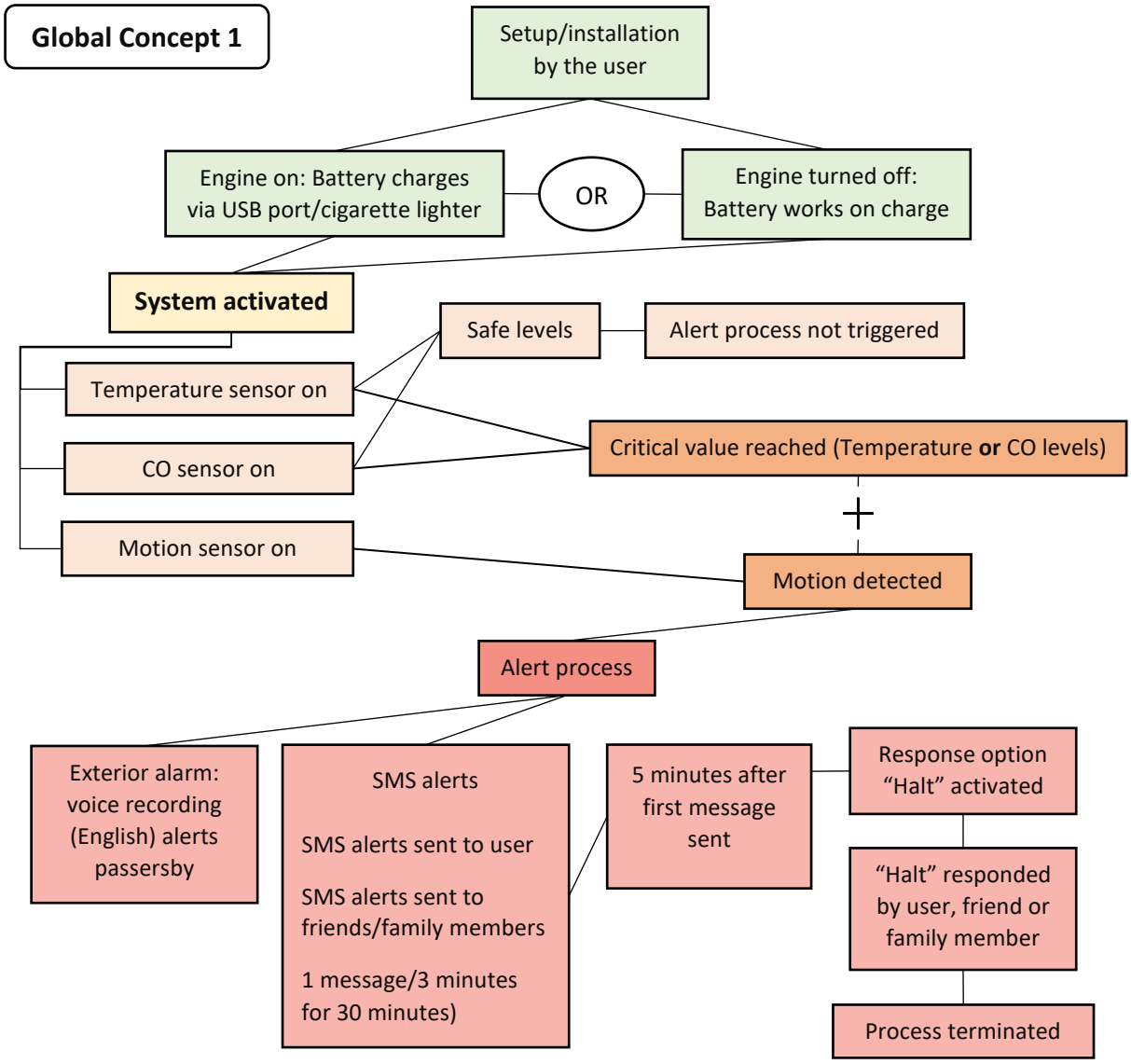

Figure 1: Global Concept 1 Flowchart

3.2 Global Concept 2

The device is set up by the customer using an app once the device is sent. It will ask the user for one or more phone numbers to be input for the device to use.

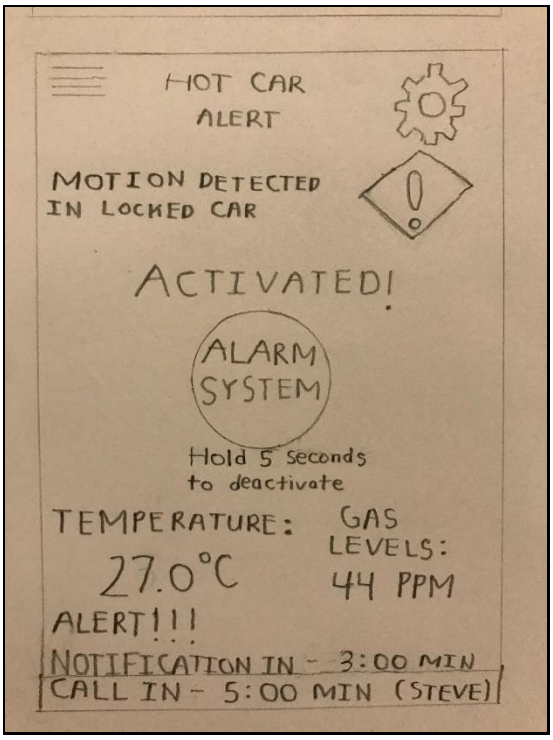

Figure 2: Application user interface design when a child/pet has been detected in the vehicle

This device will be made from multiple sensors, a control unit, and an alarm. The sensors and the control unit will be held in a plastic structure, also made of PEI. This structure will have mounts to be fitted to the headliner of the vehicle. The alarm will be fed through the car to be mounted to the engine bay. This will require a professional installation to achieve.

The device will be mounted on the headliner of the vehicle via mounts in the base of the device. The device will then be connected to the electrical wiring of the vehicle through the headliner. Thus no local battery is required and it is maintained using the car battery.

Once in use the device will monitor the levels of carbon monoxide, movement, temperature and humidity. The device will have set values for each detected variable. These variables would be identical to the ones chosen for Global Concept #1. If the readings do not deviate from the set safe levels, nothing will happen. If they do and movement is detected inside of the vehicle then the device will start the alert process.

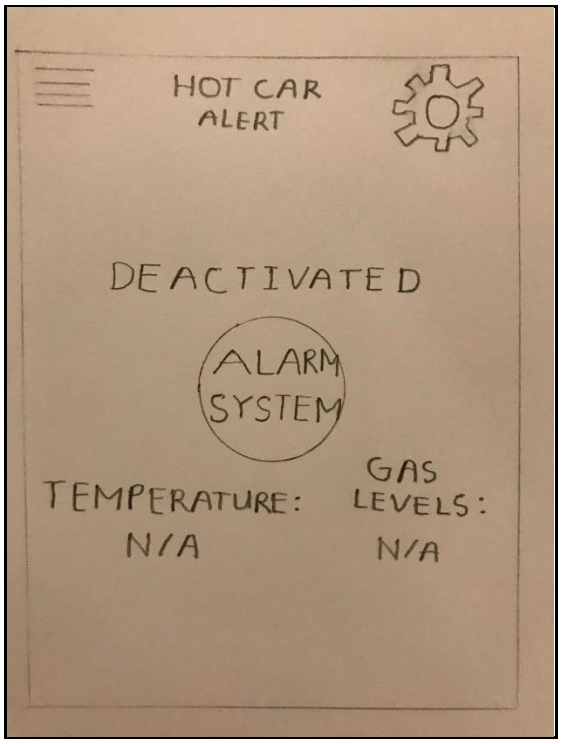

Figure 3: Application user interface design when a child/pet is not detected in the vehicle and alarm has not been activated

The app will be connected to the sensor system using cellular data. It will consist of a home screen with options to disable functionality (e.g. turn off the alarm), input phone numbers and an option to turn off the notifications after an allotted time.

Once the alert process begins a text message and notification can be sent via the app to the user, alerting him of the current danger. The text of the message will read as follows, “WARNING! DANGEROUS CONDITIONS HAVE BEEN DETECTED WITHIN YOUR OR YOUR FRIEND OR FAMILY MEMBER’S VEHICLE! PLEASE TAKE IMMEDIATE ACTION!”.

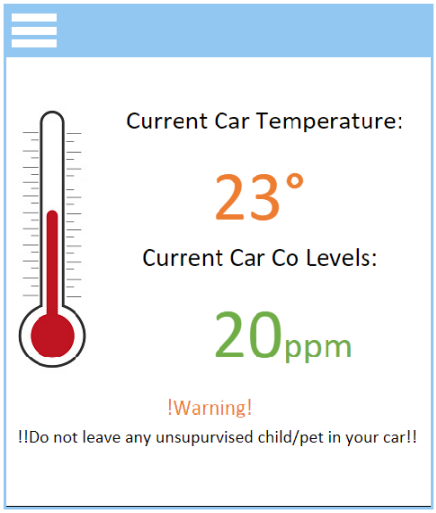

Figure 4: Temperature and gas readings in the App

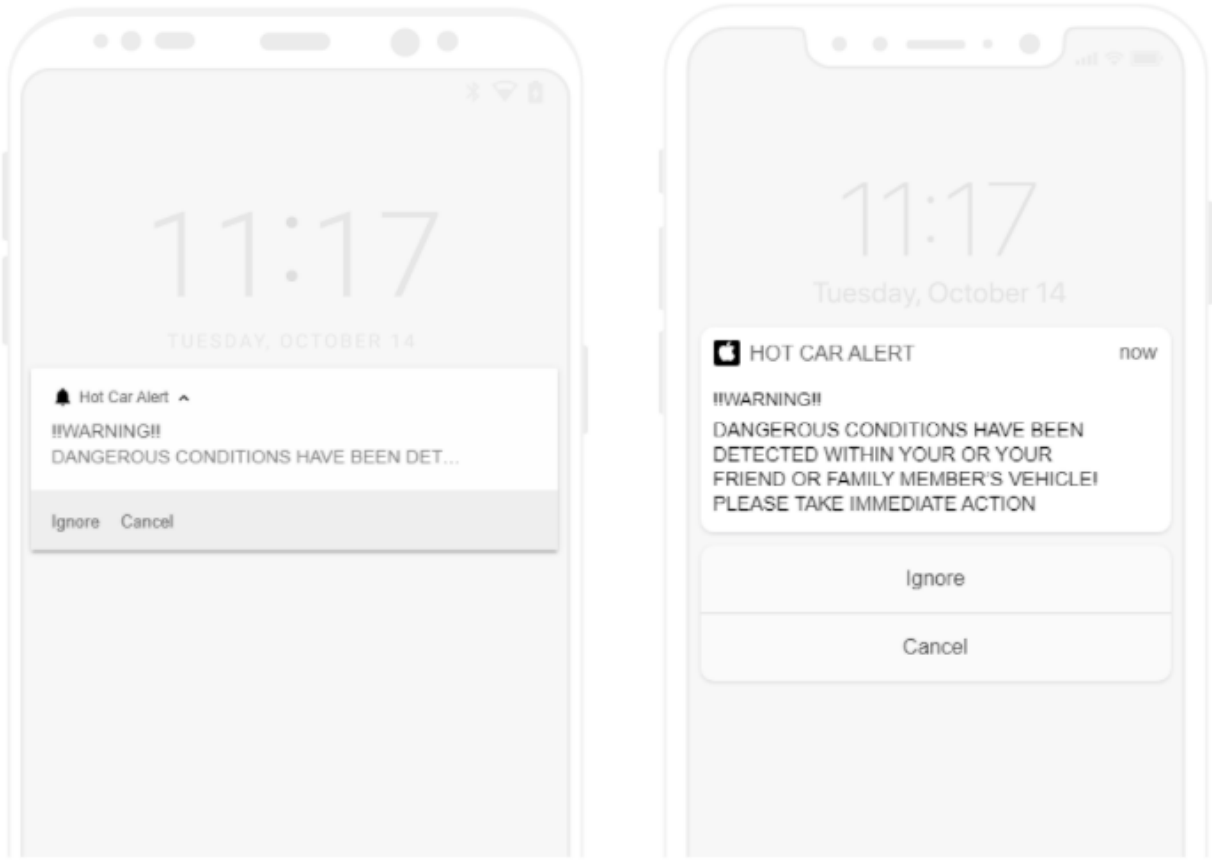

Figure 5: Notification sent out by the App in Android and in IOS

This will repeat 10 times over 30 minutes. The user can then disable these notifications via the app using a button on the home screen.

This product would have then done its job and begun its regular function.

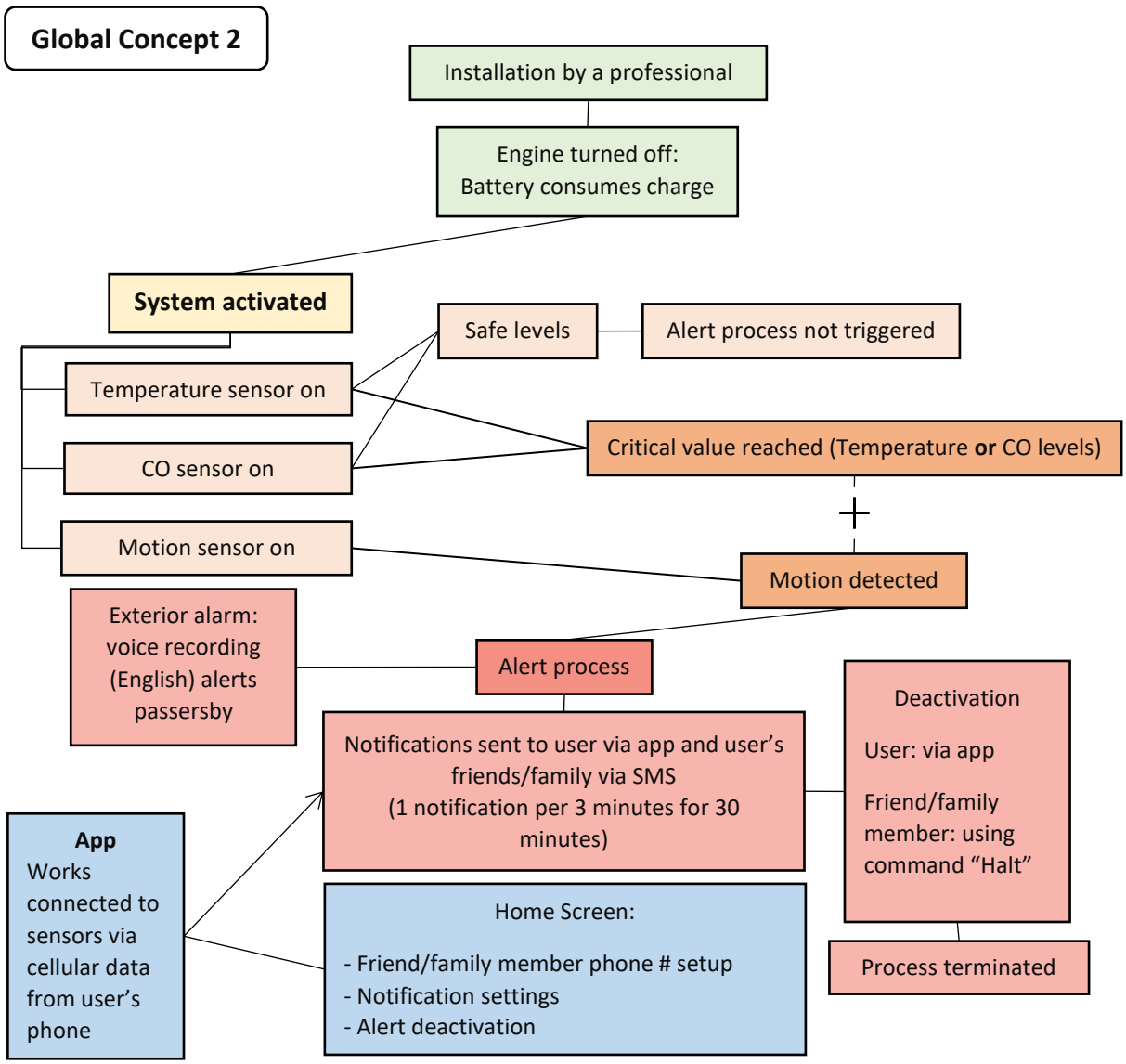

Figure 6: Global Concept 2 Flowchart

3.3 Global Concept 3

When the product is ordered by the user one or more phone numbers shall be sent to the manufacturer or supplier so that the device can be loaded with that information before it is sent to be used.

This device will be made from multiple sensors, a control unit, and an alarm. The sensors and the control unit will be held in a plastic structure (PEI). This structure will have a suction-based mount so that it can be mounted on a window or sunroof of the vehicle. Mounts and fasteners would be wrapped in Teflon for extreme temperature protection.

The device will be mounted on the headliner of the vehicle via suction cups mounted on the base of the device. This device will have an internal removable battery that will need to be recharged via USB cable when not in use. To set up the device a pamphlet will be distributed to each user.

Once in use the device will monitor the levels of carbon monoxide, movement (here using a radar sensor rather than a motion sensor, which improves the accuracy, but is more costly), humidity, and temperature. The device will have set values for each detected variable. These variables would be identical to the ones chosen for Global Concept #1 and #2. If the readings do not deviate from the set safe levels, nothing will happen. If they do and movement is detected inside of the vehicle then the device will start the alert process.

Once the alert process begins the device will start an exterior alarm to notify peoples near the vehicle. At the same time, it will send an SMS message to the user and any other set numbers to notify them about the dangerous conditions within the vehicle. The text of the message will read as follows, “WARNING! DANGEROUS CONDITIONS HAVE BEEN DETECTED WITHIN YOUR OR YOUR FRIEND OR FAMILY MEMBER’S VEHICLE! PLEASE TAKE IMMEDIATE ACTION!”. An automated call will be sent with a pre-recorded message that states the same sentence. The text messages will repeat 10 times over 30 minutes. This system can only be stopped after 5 minutes by the user responding with the text “Halt”. This instruction will be present in the paper pamphlet.

This product would have then done its job and begun its regular function.

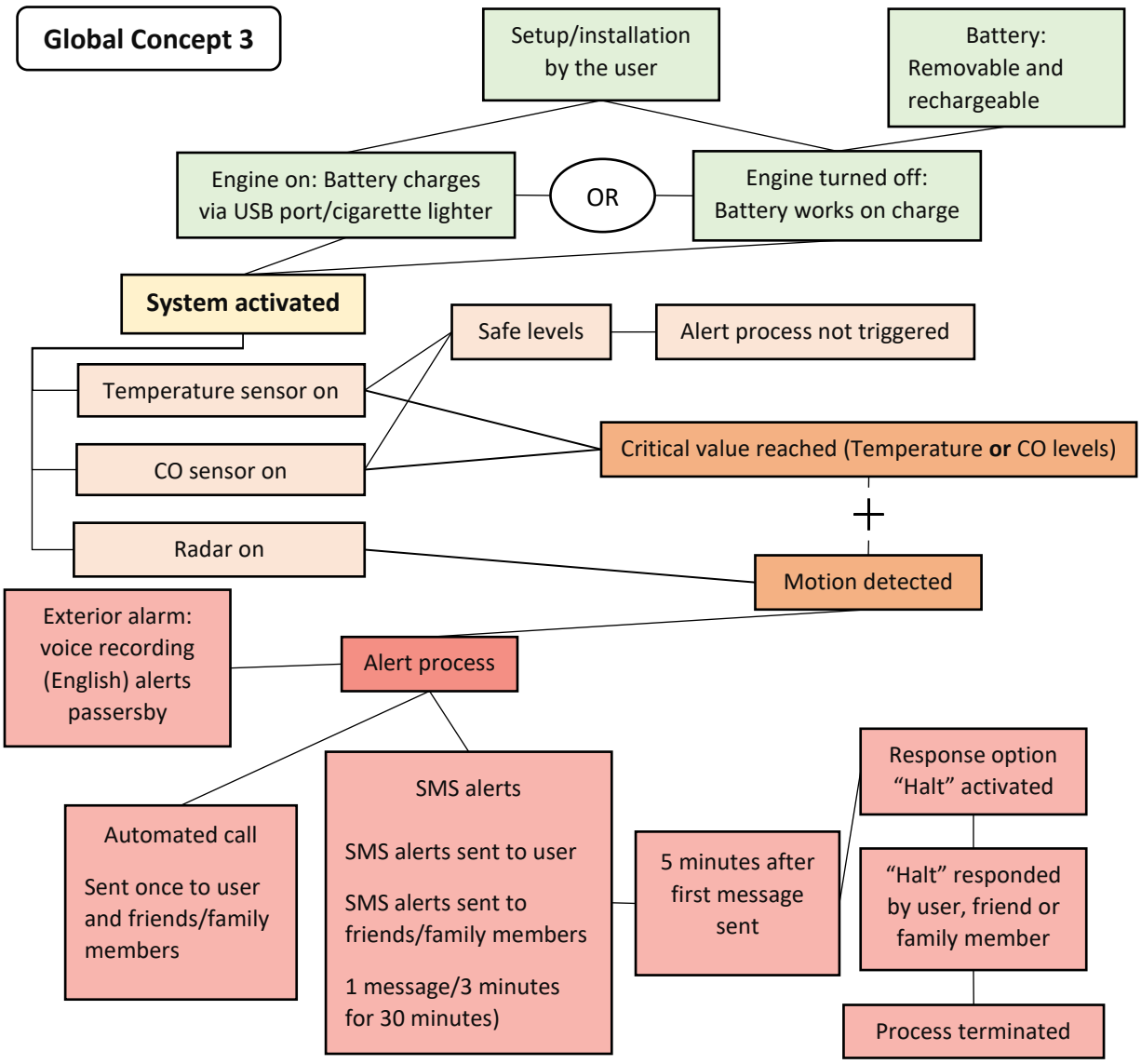

Figure 7: Global Concept 3 Flowchart

4. Comparison of Global Concepts

Table 1: Comparison of Global Concepts with Pre-determined Specifications

Product Specifications	Global Concept 1	Global Concept 2	Global Concept 3
Smartphone OS compatibility	2	3	2
Child/pet friendliness (non-distressing)	2	3	2
Cost	3	1	2
Operation in extreme environmental conditions	3	3	3
Size	3	1	2
Detection area: inside the car	3	3	3
Child and pet detection	2	2	3
Weight	3	3	3
Reliability (Battery)	3	2	2
Product life	2	2	2
Aesthetics	2	3	3
Works everywhere	3	2	3
Emergency solicited and alert scope	2	2	3
Totals	31	29	32

5. Final Global Concept

We will be using concept three going forward as it mainly offers more features to alert the client and friend/family member, as well as a more accurate detection. We were also keeping in mind feasibility based on cost constraints as well as the abilities of the team. Since we would not have to create a mobile application, more time could be attributed to refine code other components. The compatibility with all phones is the same when it comes to communicating the warning message. Though the cost of the first global concept is comparably lower than the other two, Global Concept 1 lacks important features. If it is necessary to cut costs, a possibility is to use a motion sensor for Global Concept 3 instead of a radar, but detection accuracy would be lowered, or to find a more cost-effective alternative to the suction mounts, such as Velcro. Overall, the size, weight as well as the structure make them easy to install for the user.

6. Conclusions and Recommendations

In this deliverable, we created three distinct global concepts using individually generated ideas. As each global concept unequally satisfies the client's needs, we then compared them using product specifications, established in earlier deliverables and based on the client's needs, and by rating them from 1 to 3 (from worst to best respectively). Global Concept 3 had the highest total when it came to adding up each concept's ratings. In other words, we determined this concept's detection and communication features were optimal to satisfy the client's needs. Thus, this concept will be used for the next phases of this project.