**Hot Car Emergency: Conceptual Design**

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**Abstract**

In order to produce an effective design, this document begins by defining potential subsystems of the final product. Ideas selected from a non-dismissive brainstorm session are then consolidated informally to remove redundancies and non-starters. The viable subsystem ideas are combined in a variety of ways and analyzed with respect to the design criteria outlined in deliverable C, and a plan for our final product is decided accordingly.

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# **Introduction**

As we prepare to prototype our design, it is now necessary to decide which design features we will attempt to implement. This will both address conflicts of ideation among team members and streamline our iterative process in the future. A key part of our conceptual design will be brainstorming, but we must first define the basic subsystems for which ideas will be produced.

# **Subsystem Definitions**

The device may make use of the following subsystems:

1. **Carbon monoxide**

Includes any design features that pertain to the detection of carbon monoxide or the prevention of carbon monoxide poisoning through non-mechanical means.

1. **Temperature**

Includes any design features that pertain to the detection of elevated temperatures or to the prevention of heat stroke through non-mechanical means.

1. **Occupant detection**

Includes any design features that allow the device to detect occupants locked inside of the vehicle.

1. **Communication**

Includes any design features that allow the device to interact with users, passersby, and local authorities.

1. **Mechanical**

Includes any design features that define the physical capabilities—and consequently many of the physical attributes—of the device.

# **Subsystem Consolidation**

This section addresses many of the ideas proposed for each subsystem as part of the inclusive brainstorming session, whose results are included in appendix B. Those listed in red are not currently in consideration for the final design.

1. **Carbon monoxide**
   1. MQ9 carbon monoxide sensor
   2. Catalytic filter (air purifier)

1.1. The methods of CO detection are quite limited; one specific example of a sensor is included, but most sensors function in a similar manner.

1.2. An air filter, while potentially useful, would draw massive amounts of power. Additionally, it would not address the root cause of CO poisoning, which is poor air exchange.

1. **Temperature**
   1. DHT11 temperature/humidity sensor
   2. Built-in fan

2.1. Much like CO sensors, many temperature sensors are analogous to their counterparts. Regardless, the specific nature of their functionality is irrelevant. What matters is that this sensor would allow the device to determine when extreme measures are appropriate.

2.2. A built-in fan, much like the aforementioned air filter, would not exchange air inside the vehicle. In an emergency situation, it would simply recirculate superheated air.

1. **Occupant detection**
   1. Parallax PIR Motion (infrared) sensor
   2. Ultrasonic proximity sensor
   3. Phone accelerometer
   4. Weight sensor

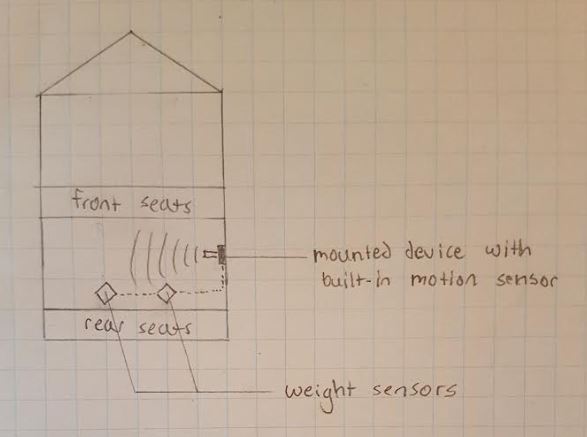
3.1. The subsystem in question must be able to detect multidirectional motion at longer ranges.

Overall an infrared sensor is the most practical and consistent option.

3.2. The ultrasonic proximity sensor we learned about in the laboratory isn’t exactly what we’re looking for; It is indifferent to motion in (relatively) far-away areas of the vehicle.

3.3. A phone accelerometer can only detect motion in the case that the potential victim has a connected phone on their person. Members of the demographic we are trying to detect do not typically possess smartphones.

3.4. Strategically placed weight sensors may be extremely valuable, as they would allow the system to detect unmoving occupants (e.g. sleeping babies). Unfortunately, they would complicate the installation, and the connection would be vulnerable to damage.



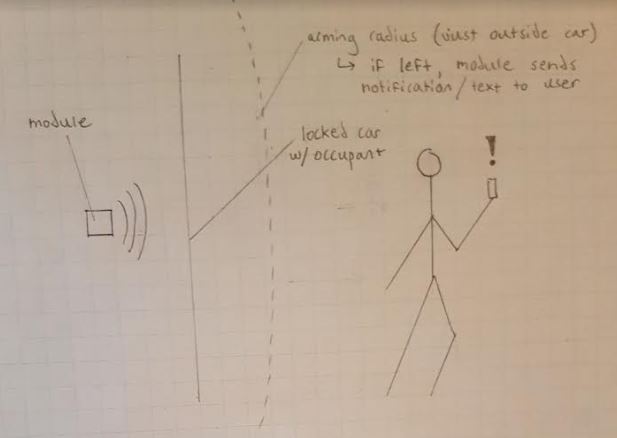
1. **Communication**
   1. Car alarm
   2. Built-in indicator (LED, Buzzer)
   3. SIM800L GSM/GPRS Module
   4. Associated app
      1. Multi-language support

4.1. While it would be ideal to use the car’s alarm system to notify passersby, this would have to be achieved through an additional mechanical system that we do not believe the device can support.

4.2. Outsiders and vehicle occupants could be notified using a built-in indicator, but in the case that primary users are already making use of an app, they would find this feature redundant. It is also assumed that those trapped inside the vehicle do not have the mental faculties to free themselves, regardless of warnings from the device.

4.3. This module will allow our device to detect the absence of the primary user, and to communicate with that user through the app. Perhaps the most important component of the device.

4.4 With the omnipresence of smartphones in everyday life, the device would have little chance of failing to contact the user through a background app (provided it is running). While having a multi-language app would make the device more versatile, careful review by native-level bilinguals would be required to ensure professionalism.

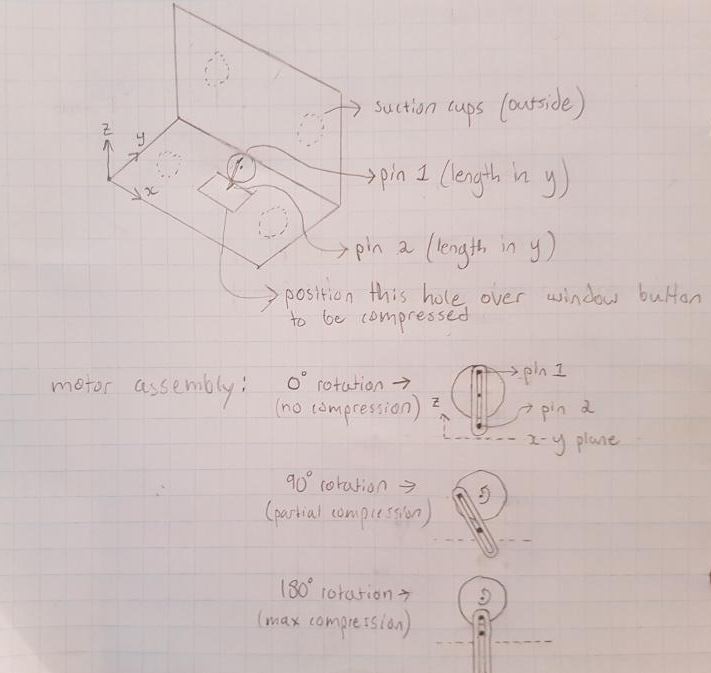


1. **Mechanical**
   1. Adjustable dimensions
   2. Attachment
      1. Adhesive
      2. Suction cups
      3. Screws
   3. Window opener
      1. Break window
      2. Servo motor (button pusher)

5.1. Adjustable dimensions were decided to be impractical, as a stable installation is required in order to protect the microcontroller (Arduino). Also, it is not clear, based on the form of a typical car door (interior), that any variability in the device’s dimensions would increase the design’s versatility; a simple hinge shape as indicated in the rough sketch below should suffice.

5.2. The client expressed a general distaste for ‘messing with the vehicle’. Thus, it was decided that neither adhesives nor permanent attachment devices (e.g. screws) would be appropriate.

5.3. To ensure safety, client satisfaction, and most of all, customer satisfaction, the device will not break the window of the car as a means to achieve airflow. Instead, a servo motor would drive what is essentially a piston in order to compress whatever button opens the window.



# **Global concepts**

The following are combinations of subsystems that have the potential to produce an effective design. These options represent only a small portion of what is possible; the final design may not conform to these standards.

1. Carbon monoxide/temperature mobile app alarm + weight based occupant detection
2. **Carbon monoxide/temperature triggered window opener + motion based occupant detection**
3. Carbon monoxide/temperature SMS alarm + weight and motion based occupant detection

# **Analysis**

|  |  | Ratings | | |
| --- | --- | --- | --- | --- |
| Design Criteria | Importance | **Solution 1:**  Mobile app + weight detection | **Solution 2:**  Mechanical window opener + motion detection | **Solution 3:**  SMS alarm + weight and motion detection |
| Installation method | 3 | 3 | 2 | 4 |
| Physical dimensions | 3 | 3 | 2 | 3 |
| Language options | 3 | 4 | 2 | 3 |
| Heat tolerance | 5 | 4 | 4 | 4 |
| Force tolerance | 3 | 4 | 3 | 4 |
| Success rate | 5 | 4 | 3 | 4 |
| Back-up mechanisms | 4 | 1 | 1 | 3 |
| Response time | 4 | 3 | 4 | 3 |
| Function of primary mechanism | 5 | 4 | 3 | 4 |
| Carbon monoxide detection | 5 | 4 | 4 | 4 |
| Temperature and humidity detection | 5 | 4 | 4 | 4 |
| Cost | 2 | 2 | 2 | 4 |
| Communication capabilities | 5 | 4 | 2 | 3 |
| Autonomy of main mechanism | 4 | 3 | 4 | 3 |
| Occupant detection | 4 | 3 | 3 | 4 |
| **Total** |  | **206** | **179** | **217** |

Solution 1 combines the detection of high temperatures and carbon monoxide with weight based occupant detection and a mobile app to serve as the alarm mechanism. This solution was proposed due to the indication of the client’s preference for a mobile app, and ability to address multiple design criteria. Solution 1 performs well on several important criteria including high carbon monoxide and temperature detection, success rate and function of primary mechanism. Where it performs the best is with regards to the communication capabilities and language options, as a mobile app will have a great deal of flexibility to communicate different messages to different users. However, it performs poorly in the cost criteria as mobile app development would be a highly involved process requiring extra expenditures.

Solution 2 combines the detection of high temperatures and carbon monoxide with motion detection and a mechanical lever to open car windows in case of an emergency. This solution was proposed due to its ability to function independent of rescuer involvement and ability to provide air flow to the trapped passenger without delay. Thus, solution 2 performs well in the response time design criteria as well as the autonomy of main mechanism. Due to the mechanical nature of the mechanism however, it is more likely that damage to or failure of the system could impact its functionality. Thus, the success rate and function of primary mechanism dimensions have been rated lower for this solution. Although this solution is rated low in several areas, it is important to consider due to the involvement of human lives and its ability to act without intervention from others.

Solution 3 combines high temperature and carbon monoxide detection with weight and motion detection and an SMS based alert system. This solution is rated the highest among the three solutions as it performs well in several important areas. Due to the inclusion of two different occupant detection methods in the form of a weight sensor and motion sensor, this solution is rated highly in occupant detection, success rate and back-up mechanisms. In addition, this solution is the most practical in terms of installation, function of primary mechanism, and cost. However, this solution does not provide a mobile app as preferred by the client and is not capable of acting without bystander or rescuer involvement in an emergency.

All three solutions will be proposed to the client to re-evaluate client needs and functional requirements. Feedback from the client will be taken and incorporated into the prototyping stage.

# **Final Thoughts**

Upon ranking the most important design criteria from the initial client meeting and weighing each concept accordingly, we have determined that solution 3 is currently the best global concept.

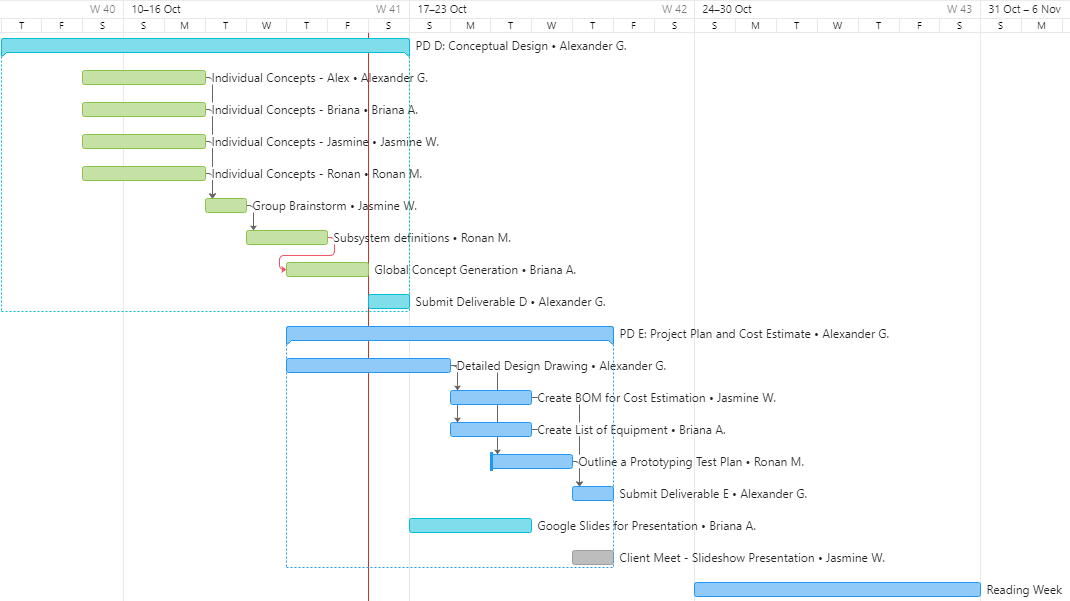
The main benefits this solution offers, as opposed to the other solutions, are its inclusion of multiple occupant detection sensors and feasibility. Because this solution features both a weight and motion sensor, it is highly unlikely that an occupant will go undetected in the vehicle. This allows for a greater rate of success in terms of occupant detection alongside a much reduced risk of false negatives. Furthermore, if one of the sensors fails, the other will be able to serve as a backup mechanism. The other advantage this solution offers is its feasibility. Compared to the other solutions, solution 3 boasts easier installation in the form of an SMS alert system instead of a phone application or physical window opener. This would also reduce the production cost, allowing it to be more affordable compared to the other global concepts.

The main drawback to this solution, however, is its application. While the use of SMS alerts make it an easier system to implement, the client has previously mentioned a desire for a mobile phone application. This drawback will thus have to be addressed in the upcoming client meeting in order to confirm whether the phone application is a necessity and if this prototype will need to be altered to accommodate this need.

# **Conclusion**

This document has demonstrated the conceptual design procedure as well as its effectiveness in coming up with solutions. After dividing the requirements into subsystems, iterating ideas via brainstorm sessions, forming various design concepts, and analysing the effectiveness of these concepts, we succeeded in designing a prototype concept that appropriately fits the client’s needs and falls within the range of our constraints. However, this prototype is tentative and the final design is likely to change with further client feedback and testing.

# **Appendix A: Task Management**



# **Appendix B: Brainstorming Session**

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