May 29, 2017

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 405W/440 Requirements Specification for ***SnoozeBud*** by ***SleepSense***

Dear Dr. Rawicz,

I am writing to you to present our requirements specifications for SleepSense's product, the SnoozeBud. The SnoozeBud is designed to help prevent toddlers from suffering sudden infant death syndrome, which is of great concern to many new parents. It features an effective and comfortable solution to this deadly issue.

The purpose of this document is to provide a high-level outline of the functionalities and requirements for our product. Included sections are a system overview, an exhaustive requirements list, engineering standards and information about sustainability and safety. The details of this document will be used as a guide during our development process.

SleepSense's team of tenacious and talented senior engineers is comprised of Alastair Scott, Bahar Baghazadeh, Blaise Crisologo and Shayne Kelly II. Our team has backgrounds in both electronics and computer engineering.

We appreciate the time you take to review our requirement specification. Please feel free to contact our chief communications officer, Bahar Baghazadeh, with any questions or concerns you may have. She can be reached at bbaghaza@sfu.ca.

Sincerely,

Alastair Scott
Chief Executive Officer
SleepSense

Requirements Specification for SnoozeBud

By

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Issued Date:

June 29th, 2017

Abstract

This document outlines the functional requirements and specifications for the SnoozeBud. Information about engineering standards, sustainability and safety are also included. This is a high-level document which will provide a complete overview of the product while keeping details simplified and concise.

The SnoozeBud consists of a breathing monitor and alarm device. The breathing monitor is placed under a baby mattress and will determine if a baby is breathing at a healthy rate while sleeping. If breathing is not being detected, a vibration will be produced as an attempt to wake up the baby. If vibration is not enough to wake up the baby, the alarm device will alert the parents so they can take actions into their own hands.

There are three main sections in this document which make up the high-level overview of our product:

- Complete list of requirement specifications, including sub sections for general, physical, hardware and software/firmware requirements. We have organized our specification numbers to separate the requirements of our proof of concept, prototype and final product.
- Engineering standards that apply to our product.
- Safety information for proper usage of the SnoozeBud
- Sustainability information

This document includes diagrams of the Snoozebud system concept and component flowchart to provide the reader with a comprehensive overview of the overall product. Our team at SleepSense aims to ensure that the product is sustainable in the long term and perform its function at the highest level. By the end of July 2017, we will be able to show a proof-of-concept of our product and have a functioning prototype by November of 2017.

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1. Introduction

The SnoozeBud is a product designed to help parents and their newborn baby get the healthy sleep they deserve. One of the greatest worries new parents have about their babies is that they may suffer from Sudden Infant Death Syndrome or SIDS. SIDS can cause a newborn baby to pass away while they are asleep. Given that parents can't keep an eye on their baby at all times, our aim to design SnoozeBud has made it possible to constantly monitor baby's health condition.

SnoozeBud will be a pad placed under the mattress, that will track a baby's breathing while they sleep to ensure they maintain a healthy supply of oxygen. If a sleeping baby stops breathing, our product will produce a strong vibration to attempt to wake them up and restart their breathing. If the vibration has occurred and the system doesn't sense the baby's breathing has returned to normal, an alarm will be set off in the parent's room notifying them that their baby needs medical attention. Our product will be thin enough to be unnoticeable by a sleeping baby on top. SnoozeBud will have a non-invasive method of measuring breathing, which is more ideal than conventional methods that require wearing a device and preventing a comfortable sleep.

Our main goal is to keep newborn babies safe and sleeping healthily. We also aim to minimize the anxiety of the parents who already preoccupied with everything else. This document is a requirements specification which will provide a high-level outline of our product's functionalities and requirements. It will also detail the engineering standards applicable and information about safety and sustainability.

1.1 Background

Health care providers and researchers have yet to find the exact cause for SIDS. However, recent studies suggest that SIDS occurs in babies born with brain defects or abnormalities [3]. These abnormalities are often seen within a network of nerve cells that communicate using serotonin. These cells are found in the section of the brain controlling functions such as respiration, blood pressure, and awakening. It is also believed that brain abnormalities alone are not enough to cause SIDS. There is also evidence that the environment factor comes into play in SIDS, and this poses a great risk to the child at certain periods of infant development. Research also suggests that hereditary health problems also play a role in the cause of SIDS.

Unfortunately, there is a lot of uncertainty in the claims made from SIDS research. There are currently only a few ways that parents can reduce the risk of SIDS for their baby. Putting your baby to sleep on their back, removing toys and blankets from the crib, letting your baby sleep with

a pacifier, and keeping the crib in your room are all practices which should be done by all parents. Simple products such as sleep positioners and ventilation mattresses can also be purchased, but don't have much evidence to show their effectiveness.

A common, more advanced type of product available for parents who want to further reduce the risk of SIDS are wearable devices that use pulse oximetry. These devices measure and track oxygen saturation. These devices work by passing two wavelengths of light through a part of the body and measure the different absorbance at each wavelength. For an infant, a device that does this would typically be attached to the foot. While this technique is non-invasive, it requires wearing a device to sleep, which is not optimal. We wanted to provide a method for tracking respiration that is discreet and causes no interference with your baby's normal sleeping arrangements, which motivated us to develop the SnoozeBud.

1.2 Scope

This document outlines the functional requirements and specifications for the SnoozeBud, and contains relevant information about safety and sustainability. All the requirements listed are to be met during the development of the product. A system overview of our product is also included to clarify how the product will work.

1.3 Intended Audience

This document is intended to be used by SleepSense members during the development of the SnoozeBud. It will function as a guide through the development process. The engineers will refer to the hardware and software requirements when creating the design. The safety and sustainability sections will be referenced during test plan creation and quality assurance testing. All requirements are intended to be met when final product is completed.

1.4 Classification

The following classification system will be used when listing the requirement specifications

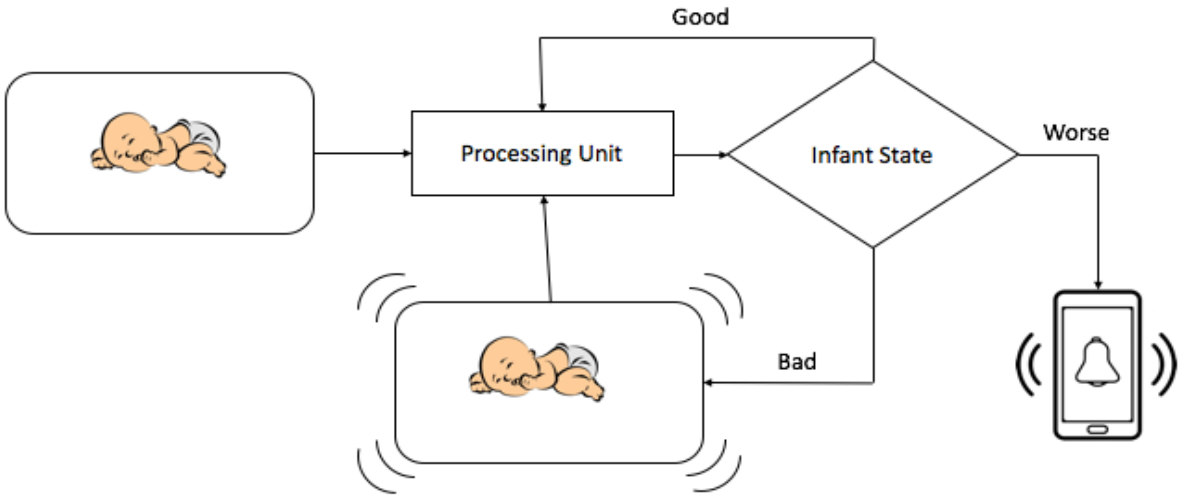
[Req X.X.X.X – YYYY]

Req stands for requirements. The X's indicate three to four integers which represent the section, sub section, sub-sub section and number of each requirement, respectively. The Y's will be PRFC, PROT or FINL which is the priority level of each requirement. The PRFC requirements will be completed for the proof of concept, PROT stands for prototype and FINL stands for final product.

2. System Overview

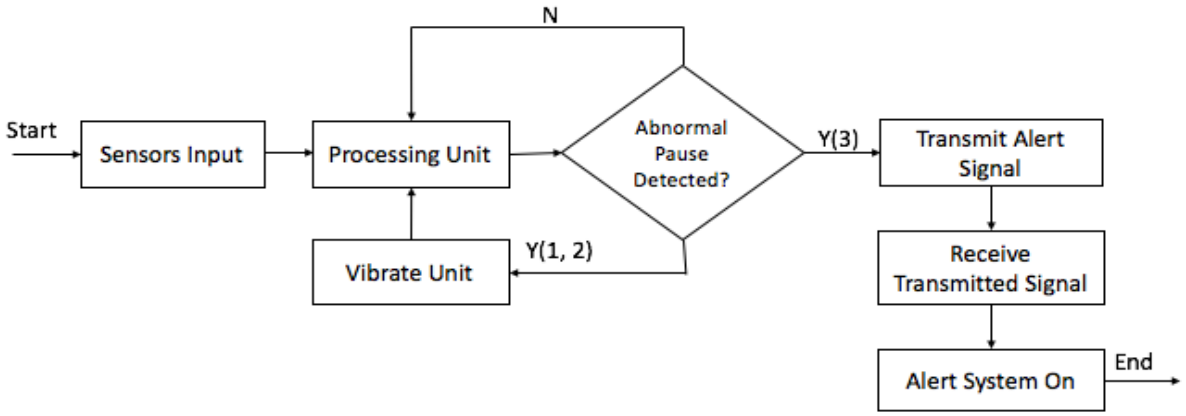
The SnoozeBud consists of two core hardware devices, a monitoring pad and an alarm device. The monitoring pad is thin and rectangular. When placed under a baby mattress, it will detect breathing movements of a baby sleeping on top. It will then interpret these breathing movements and determine if they are occurring at a constant rate. If the baby is breathing normally, nothing will happen and the baby will continue to sleep happily. However, if the breathing stops for 10 seconds, the pad will vibrate. The vibration is intended to wake up the baby, and the vibration strength can be adjusted with a switch on the bottom of the device. If the baby does not wake up and start breathing after two vibrations, a signal will be sent to the alarm device. This will alert the parents that their baby has stopped breathing and they can handle the situation from there. A flow chart of the system can be seen below.

Figure 1: Conceptual Overview of SnoozeBud



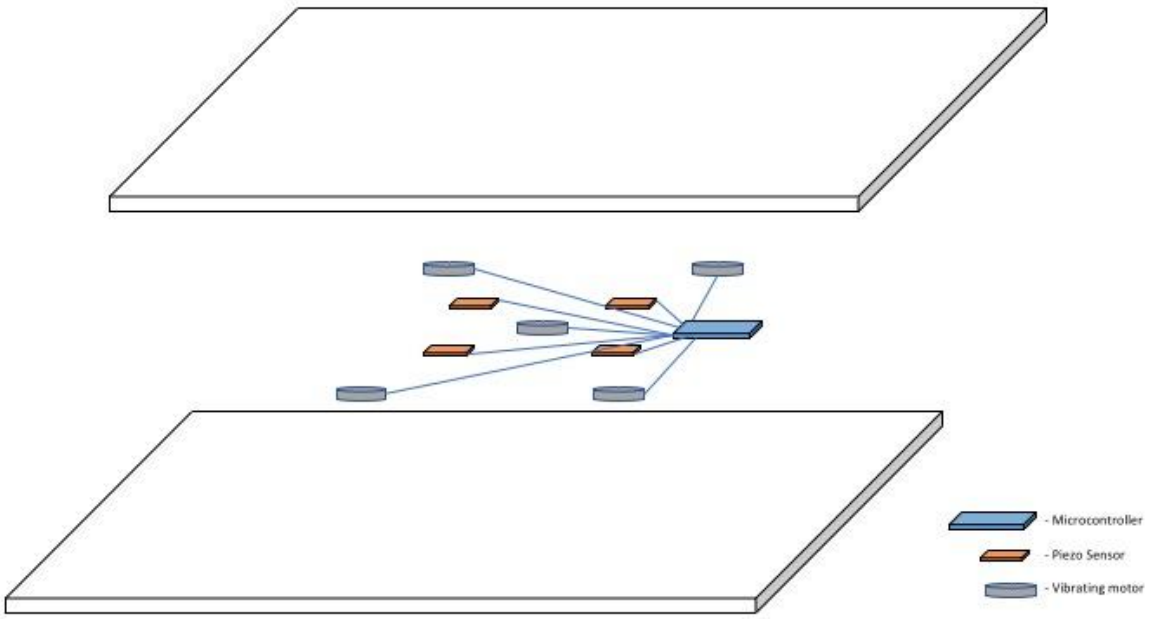
The monitoring pad will keep track of breathing using piezoelectric sensors. A healthy sleeping baby will be constantly producing small movements when inhaling and exhaling on top of the mattress. The piezoelectric sensors are can sense these small movements. A vibration motor is also included in the monitoring pad, which will be activated if breathing is no longer being detected at a steady rate. All computing within the monitoring pad will be done by an Arduino Uno R3 microcontroller board. The monitoring pad and the alarm device will communicate wirelessly, and the Arduino will send an alarm signal to the alarm device if it detects the infant has stopped breathing. The system block diagram of the SnoozeBud is presented in Figure 2.

Figure 2: SnoozeBud Block Diagram of System



The electronic components will be placed inside the covering of the SnoozeBud. As seen in Figure 3, the white planes indicate the device covers. Inside the covering, there will be multiple sensors placed on a large section for accurate detection. Alongside it will be small vibrating motors spread out for more coverage. All the equipment will be linked to the microcontroller.

Figure 3: SnoozeBud Electronic Components Layout



3. System Requirements

The following sections will outline all the requirements of the SnoozeBud. These requirements include general, hardware, software and safety requirements.

3.1 General Requirements

Req 3.1.1 – PRFC	The system will cost under $200
Req 3.1.2 – PRFC	The device is intended for babies 0-12 months old
Req 3.1.3 – PRFC	The Snoozebud is intended for inside use
Req 3.1.4 – PRFC	The device will turn on when plugged into a wall outlet
Req 3.1.5 – PRFC	A switch will be included to adjust the vibration motor strength
Req 3.1.6 – FINL	The user manual will be packaged with the product
Req 3.1.7 – PRFC	Operating temperature will be -30 to 70 degrees Celsius
Req 3.1.8 – PRFC	Maximum operating altitude will be 5000ft
Req 3.1.9 – PRFC	Intended humidity will be 10-90%

3.2 Physical Requirements

Req 3.2.1 – PRFC	The product includes a monitoring pad and alarm device
Req 3.2.2 – PRFC	The monitoring pad will not exceed dimensions of 20 inches long, and 15 inches wide
Req 3.2.3 – PRFC	The monitoring pad will fit comfortably under the crib mattress
Req 3.2.4 – PRFC	The monitoring pad will be able to withstand a weight of up to 100lbs without damage
Req 3.2.5 – PRFC	The switch to adjust the vibration motor strength will be on the bottom of the device
Req 3.2.6 – FINL	All inputs, outputs and controls will be labelled clearly
Req 3.2.7 – PRFC	The Snoozebud will function correctly for babies of any size, until they reach one year of age
Req 3.2.8 – PRFC	A small LED will light up when the device is plugged in

3.3 Hardware Requirements

The components of the hardware requirements consist of multiple Piezo vibration sensors which will monitor the subject's movement on the SnoozeBud. Data obtained from the sensor's inputs will be analyzed using an Arduino Uno R3 microcontroller board. If abnormalities are detected, the Arduino R3 will initiate the vibrating motors for a short period of time. For the proof of concept, the communication link of signaling alerts will be through the USB to a computer.

3.3.1 Piezo Vibration Sensor

Req 3.3.1.1 – PRFC	The sensor produces a small AC and large voltage of up to +/-90V
Req 3.3.1.2 – PRFC	There will be multiple Piezo Vibration sensors spread across the mattress pad's inner sheet.
Req 3.3.1.3 – PRFC	The sensors will be attached to the main circuit border for analysis of inputs and shall not be disconnected from the linked modules.

3.3.2 Arduino Uno R3 Board

Req 3.3.2.1 – PRFC	The microcontroller will have an operating voltage of 5V.
Req 3.3.2.2 – PRFC	The microcontroller would require an input voltage ranging between 7 to 12V.
Req 3.3.3.3 – PRFC	The microcontroller will be powered using a 12V AC power supply to meet the required input voltage in section x.x.2.2 (previous).
Req 3.3.3.4 – PRFC	The operating clock speed of the microcontroller will be at 16MHz.

3.3.3 Vibrating Motor

Req 3.3.2.1 – PRFC	There will be a layout of thin vibrating motors inside the mattress pad.
Req 3.3.2.2 – PRFC	The vibrating motor will be operating between 2.2 – 3.6V DC and up to 90 mA.
Req 3.3.2.3 – PRFC	The motors will be linked and controlled by the microcontroller.
Req 3.3.2.4 – PRFC	The vibrating motors shall not be disconnected or disassembled from SnoozeBud.

3.4 Software and Firmware Requirements

There are two components of software and firmware that will be interfaced together. The first will be the firmware designed for the operation of the SnoozeBud monitoring system. The second component is the software application that will run on a user's smartphone to alert parents or guardians if the SnoozeBud fails to wake the child after a lapse in breathing.

3.4.1 Breathing Monitoring System and Vibration System

Requirements for the firmware on the Arduino board are outlined in this section. This firmware is responsible for controlling the breathing monitoring system and the vibration wake-up system.

Req 3.4.1.1 – PRFC	The firmware will interface with sensors used to monitor an infant's breathing in real-time.
Req 3.4.1.2 – PRFC	The firmware will control a vibrational motor used to attempt to wake an infant.
Req 3.4.1.3 – PRFC	The firmware will trigger a vibration after detecting a 5 second lapse in breathing.
Req 3.4.1.4 – PRFC	The firmware will interface with a user's smartphone.
Req 3.4.1.5 – PRFC	The firmware will send an alert to the user's smartphone if breathing is not observed within 5 seconds of a vibration.
Req 3.4.1.6 – PRFC	The firmware will only monitor breathing when the weight of an infant is detected.
Req 3.4.1.7 – PROT	The firmware will interface with lights indicating power on, ready to monitor breathing, and vibration strength.
Req 3.4.1.8 – PROT	The firmware will initialize less than 10 seconds after the power button is pressed.
Req 3.4.1.9 – FINL	The firmware will be upgradeable via communication between Arduino and the user's smartphone.

3.4.2 Smartphone Alert Application

Requirements for the smartphone application that interfaces with the breathing monitoring system are outlined in this section.

Req 3.4.2.1 – PRFC	The application will run on the Android operating system.
Req 3.4.2.2 – PROT	The application will run on the iOS operating system.
Req 3.4.2.3 – PRFC	The breathing monitoring system will interface with the application via WiFi.
Req 3.4.2.4 – PRFC	An alarm will sound at a user-configurable volume when triggered by the breathing monitoring system.
Req 3.4.2.5 – PROT	The user interface of the application will be simple and clear.
Req 3.4.2.6 – PROT	Help and setup information will be displayed on the application.
Req 3.4.2.7 – FINL	The application will interface with smartphone screen readers for visually impaired users.
Req 3.4.2.8 – FINL	The application will show a list of all abnormal breathing events detected by the breathing monitoring system.

3.4.3 Android Operating System Specific

Req 3.4.3.1 – PRFC	The application will run on Android 5.0.1 (Lollipop) or newer.
Req 3.4.3.2 – PROT	The application will be downloadable and upgradeable through the Google Play Store.

3.4.4 iOS Operating System Specific

Req 3.4.4.1 – PROT	The application will run on iOS 10.0.0 or newer.
Req 3.4.4.2 – FINL	The application will be downloadable and upgradeable through the Apple App Store.

3.5 Safety Requirements

Req 3.5.1 – PROT	Hazardous electronic components should not be placed on top of the monitoring pad.
Req 3.5.2 – PROT	The product will be devoid of any toxic or harmful chemical substance.
Req 3.5.3 – FINL	Wires will not be left dangling anywhere close the mattress but will be capped and hidden in a box
Req 3.5.4 – FINL	The product will be free of sharp edges
Req 3.5.5 – FINL	All of the electrical components used in the system, will be placed in a waterproof box
Req 3.5.6 – FINL	This device should be resistant to the force exerted from the mattress
Req 3.5.7 – PROT	Device should be easy to transport
Req 3.5.8 – PROT	The material used in the pad, will not be flammable, or explosive
Req 3.5.9 – PROT	Electrical charge on the pad will be tested and controlled to stay within a safe limit inside of the box
Req 3.5.10 - PROT	Device will be easy to transport

4. Sustainability

Among various primary goals determined for this product, at SleepSense our primary focus is to develop a sustainable product. We believe in the significance of sustainability as it not only guarantees the present needs of the infant, but also ensures that the future of an infant is not compromised by his/her current needs. To further investigate the concept of sustainability, we

should analyze various aspects of a sustainable product including environmental recycling and social impacts.

Regarding the recent concerns about the environmental footprint of electronic devices, at SleepSense, our intention is to minimize the harmful impact of the product and to increase its performance. To achieve this goal, we focus on the material use, energy consumption and the end life of the product. The mentioned factors are considered at every stage of the product's life cycle as well as its final disposition and recycling. Primarily, our electronics' parts are selected and designed, using a cradle to cradle model. In this model, the components are intended to remain in a continuous cycle, with the aim of reusing the parts after their lifecycle to create new materials. Most of the parts are back to the technical and biologicals cycle. Using this method, the quality, efficiency, and performance of the product is maximized.

At the prototype phase, our ambition is to reuse the previous components to keep them in the technical cycle. This reuse assists us to minimize the impact of the material on the environment after the life cycle is over. At the end of the testing phase, we will disassemble the components into two categories: components that can be reused and components that are required to be recycled. SleepSense will implement this strategy after used products are recollected from customers for recycling. On the other hand, the design of SnoozeBud has made it possible to use a simpler disassembly process for easier recycling.

On the other hand, the chosen materials used in the design of SnoozeBud contain minimum hazardous chemicals. The plastic pad will be built from biodegraded plastic material which are found to contain less environmentally hazardous chemicals. Heavy metals used in wires and soldering, are also considered to have negative impacts on the environment. Reuse of wires is another feasible approach in cradle to cradle design that we will be leveraging during our design process. The material used in packaging at mass production phase, must be made from recycling paper containing less environmentally harmful chemicals. From a social point of view, SnoozBud, improves the quality of life and enhances public health by fulfilling future generations' needs.

With the aid of cradle to cradle design methodology, SleepSense provides an environmentally sustainable product. To maintain this sustainability, we provide training and documentations on how to recycle the product after use. Also, as SnoozeBud has a limited lifetime, based on the growth of infant, its useful lifetime can be significantly increased by reusing, even before recycling and breaking apart.

5. Conclusion

As there are a number of potential causes for Sudden Infant Death Syndrome, it is imperative that a monitoring device be used to assure parents that their child is sleeping safe. The available monitoring devices on the market for infants are split between a wearable device for the child or an active monitoring device such as baby cameras. Wearable devices are in nature, intrusive for

the user, and can be potentially hazardous for the baby while it is sleeping. Active monitors such as baby cams require consistent attention from the parents, which is impractical during parents' sleeping hours.

Given the limitations imposed by competing companies, we believe our product offers a different approach to alleviate the stress of parents. With SnoozeBud, parents do not have to constantly check on their child as our product will alert them if the state of the child is in critical condition. This can give assurance to parents who are constantly anxious about their child's safety.

The functional requirements and specifications listed in this document will be used as a guide during the future of our design and development process for our hardware and software. Sustainability is also a major priority to SleepSense and will be an influencing factor of all design decisions. The requirements have been categorized by whether they apply to the proof of concept, prototype or final product. At the end of July we will have our proof of concept completed, the prototype will be complete in the fall and the final product will be completed at the end of November.

If time permits, we will be adding essential features to our final model. This includes but not limited to: active baby monitor as it is a highly demanded feature for consumer devices, and potentially a carbon dioxide level detector to ensure there environment does not inhibit the infant's breathing cycle.

6. Appendix

This appendix outlines the functionalities that will be implemented by the end of the proof-of-concept stage. These are the minimum deliverables for the ENSC 405W poster presentations.

Functional Requirements for Proof-of-Concept

The monitoring pad will monitor the breathing of an infant (of up to 1 year of age) in real-time.

When a lapse of breathing of 5 seconds is detected, a vibration will be triggered to attempt to wake the infant. If breathing is not detected 5 seconds after the vibration, an alert will be generated on the alarm device connected to the monitoring pad.

The monitoring pad will include a small LED that will indicate whether the device is powered on.

The monitoring pad will also include a switch to adjust the strength of the vibration motor (for waking the infant).

Physical Requirements for Proof-of-Concept

The proof-of-concept will include a monitoring pad that tracks an infant's breathing, as well as an alarm device.

The monitoring pad will be less than 20 inches long and 15 inches wide, and should be small enough to fit comfortably under the infant's mattress. The monitoring pad should also be able to withstand up to 100 lbs of weight.

The sensors and the vibrating motor should be packaged in the monitoring pad, and not easily accessible to users to disassemble.

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