

## UNIVERSITY OF OTTAWA – FACULTY OF ENGINEERING

ENGINEERING DESIGN

GNG1103

Project Deliverable D: Conceptual Design

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# Abstract

Our goal is to design a product that accurately detects an overdose due to opioid use. The device should signal for help, while providing the location of the user in under three minutes so that naloxone can be administered. It is important for the device to be discreet, have at least one day's battery life, and not interfere with drug use. The device works by detecting blood oxygen concentration using a pulse-oximeter. Measuring respiratory rate is also an asset to accurate detection of an opioid overdose. Individual brainstorming was an important step to integrate our ideas into three final proposals, which we can continue to develop throughout the course of the design project. A watch-style opioid overdose detector gives the user the sense of using day-to-day technology, and is capable of containing all the technology in one location on the body. The second design focuses on subtlety, as well as convenience, by including all features in a slip-on sock. Finally, another design works as a single sticky patch that can be attached on any thin part of the body. This proposal compromises respiratory detection, but in turn provides a more streamlined design.

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# **1.Introduction**

Considering the rate of the use of opioids, it is becoming more tasking to prevent opioid overdose deaths and now more focus is being directed to harm reduction of opioid overdose. With an aim to reduce the rate of harm caused by the use of opioids, the client - Tali Cahill requires a device that would help detect an overdose and send an alert for help within reasonable time. This device would be able to monitor an opioid user by constantly evaluating necessary values read from the body. In order to meet the requirements of the client the device must be discreet and accurate. Basically everyday across the country, there are people who use opioids and are at risk of overdosing. This ranges from those working in corporate organizations to those using alone and on the streets. The overdose device would help reduce the rate of deaths while staying within the defined constraints. It would be a small, lightweight device that would prove efficient in achieving the goal of the client. Additionally, the opioid overdose monitor would be designed in such a way that it would be used daily without disrupting daily activities.

### 1.1 Problem Statement

To reduce harm from an opioid overdose, there is a need for a portable, discreet, non-intrusive and cost effective device that efficiently detects an overdose and sends a call for assistance within a timespan of less than three minutes.

# 2.Need Identification and Product Specification Process

### 2.1 Client Meeting

The client meeting was essential to start the conceptual design due to the fact that the client confirmed some of our assumptions, such as the device has to be easy to use, capable of being used for an entire day, accurate, cheap and non-intrusive. The client also presented some essential features that were unknown to our group like, the device cannot be dependent on the use of the fingers because many users have opioid on the fingers making the reading of saturation of oxygen hard to be made, the device has to be not only discrete but an

indistinguishable day-to-day device. If it is not hidden underneath clothing in order to avoid discrimination against opioid users.

## 2.2 Needs and Prioritization

Although the group thought about many useful and interesting features, the priority is on the accuracy of the device and the safety of the user. The device has to be designed in a way that the accuracy is positively affected, for example, the device has to be located in a part of the body where the saturation of oxygen can be determined with precision. The device has to be non-intrusive in order to preserve the safety of the user, avoiding any kind of possible infections and also, an indistinguishable device because if it is not the user will possibly abstain the use of the device in some occasions where it can be seen, therefore, making the user unsafe in a case of an overdose.

## 2.2 Benchmarking

Throughout the process of Benchmarking a few similarities between related devices in the market were found, all the devices are super light, making the user feel comfortable using them. They are mostly under \$100 and have a watch size. Also, all the devices are used on the user's arms, pursue a battery that lasts at least one day and detects the user's saturation of oxygen. None of the devices have the features that are essential to the group's device such as being capable of signing for help, give user's location without the use of a cell phone and inhibit drug use. Therefore, there are similar devices in the market but our device is unique for having more and improved features.

	(weight)	Carnegie Mellon University: "HopeBand"	SmartWatc h P68	Biosensor	Purdue university
cost	(3)	\$16-\$20 US	33\$	n/a	20\$
weight	(4)		.18lbs	.27lbs	166.6± 5.3mg(device) 11.5±0.9 drug
battery-life	(4)		5-7 Days	n/a	Portable battery

size	(4)	Wearable Watch-Style	248mm(bra celet length)	Smartwat ch size	Wearable Armband 2.88 diameter, 8mm length
customizable	(3)		no	Yes	no
accuracy	(5)	n/a (currently improving prediction accuracy)		86.78%	n/a
intrusive?	(4)	no	no	no	Yes (self administer naloxone)
Inhibit drug use?	(5)	no	no	no	no
Measure respiratory rate and oxygen concentration	(5)	Only detects oxygen concentration with pulse oximetry	yes	yes	yes
Override system	(2)		no	yes	no
Signal for help	(5)		no	NO	no
Give user's location	(5)	Bluetooth connects device to the user's smartphone: sends accurate GPS location to emergency contacts	no	NO	no
Error percentage	(4)			9.04%-13. 22%	n/a

Table 1. Design Features of Benchmarks

# 2.3 Design Specification

	Design Specification	Relati on	Value	Units	Verification Method
	Functional requirements				
1	Percentage error	<=	5	Percent	Test
2	Monitoring Time	=	10	second	Test
3	Battery Life	>=	1	day	Test
4	GPS tracking accuracy	<=	10	metre	Test
5	Customizable	=	yes	n/a	Test
6	Override System	=	yes	n/a	Test
7	Detects overdose	=	yes	n/a	Test
8	Non-invasive	=	yes	n/a	n/a
	Constraints				
1	Size	<	6.5	inches	Measure size
2	Weight	<	1	lb	Weight device
3	cost	<	100	\$\$\$	Calculate price
	Non-Functional Requirements				
1	Discreet	=	Yes	n/a	Survey
2	Location of application	n/a	n/a	n/a	n/a

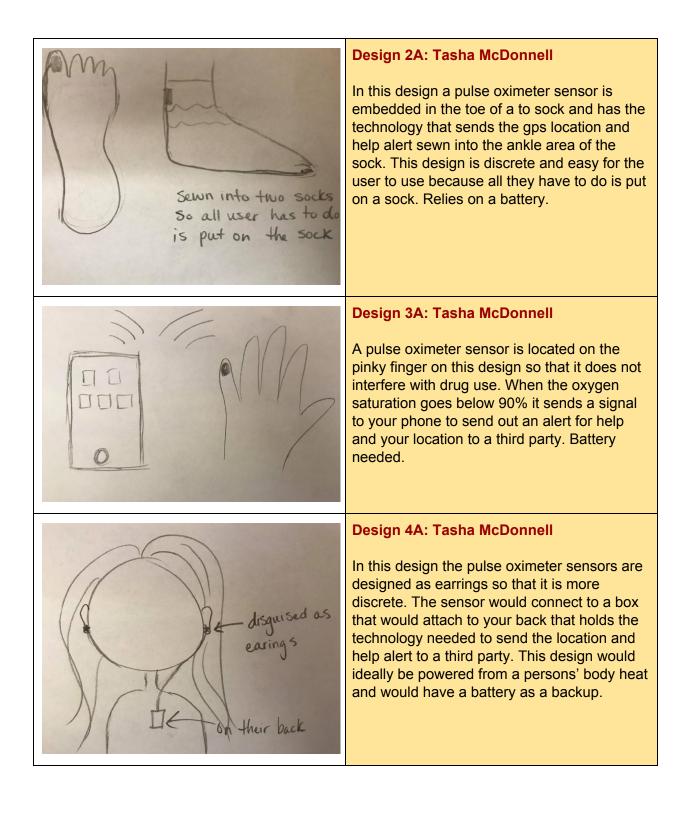
Table 2. Design Specifications

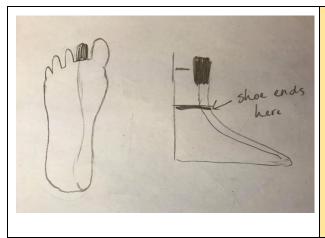
The group is working towards a non-intrusive device that can prevent opioid users from dying of an overdose by detecting an overdose with 95% accuracy and, sign for help with the user's location within an accuracy of 10 meters. The detection of overdose is made by monitoring the user's saturation of oxygen and heart hate every 10 seconds, seeing that people may have different standards of heart rate and saturation of oxygen the device is customizable, making it fit for any user. The device has to be accessible, the price of \$100 makes it acceptable to most of the population seeing that the device can save the user's life. In order to avoid any kind of discrimination the device can not be visually tellable that it is destined to opiod users, therefore, it has to be hidden or disguised as a day-to-day accessory. It has to be small, around 6.5 inches it's the most optional size seen that is discreet, easy to disguise and wear. The battery has to last at least one day so the user does not have to worry if the device stops working during the day. The device has to be light in order to not incommode the user during its use, ideally weighing less than 0.4 lbs. An override system is needed in case of the 5% margin of error is triggered.

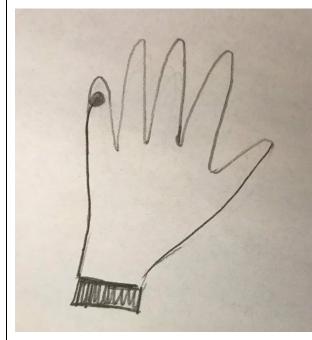
# 3. Global Conceptual design

Sketch	Detailed Description
	Design 1A: Tasha McDonnell This design uses a pulse oximeter sensor located on the earlobe attached to headphones (to make it discrete). The pulse oximeter will measure the oxygen saturation and when it is below 90% it will send a signal to an application on your phone which will send your gps coordinates and a text to alert them that you need help. This design would use a battery.

## 3.1 Brainstorming







#### Design 5A: Tasha McDonnell

This device is similar to the toe sock design, in this design a pulse oximeter sensor is placed on the toe (not the big toe or pinky toe as they are the most important for walking) and sends a signal to a box located above the shoe line (so it doesn't interfere with clothing) that holds the gps and help alert technology. When oxygen saturation is below 90% it sends an alert for help. Battery needed.

#### Design 6A: Tasha McDonnell

In this design a pulse oximeter sensor is located on the pinky finger (to not interfere with drug use) and sends a signal to a watch (discrete) located on the wrist if the oxygen saturation goes below 90%. It would then send out a help alert and the GPS coordinates to a third party. There is also a button on the watch that allows you to override an alert for help if you are not actually overdosing. This design would require a battery.



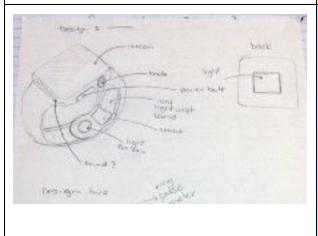
#### Design 7A: Tasha McDonnell

This design also has a pulse oximeter located on the pinky finger (to not interfere with drug use) and send a signal to a ring (discrete) if the oxygen saturation goes below 90%. The location and help alert would be sent from the ring. This design would require a very small battery.



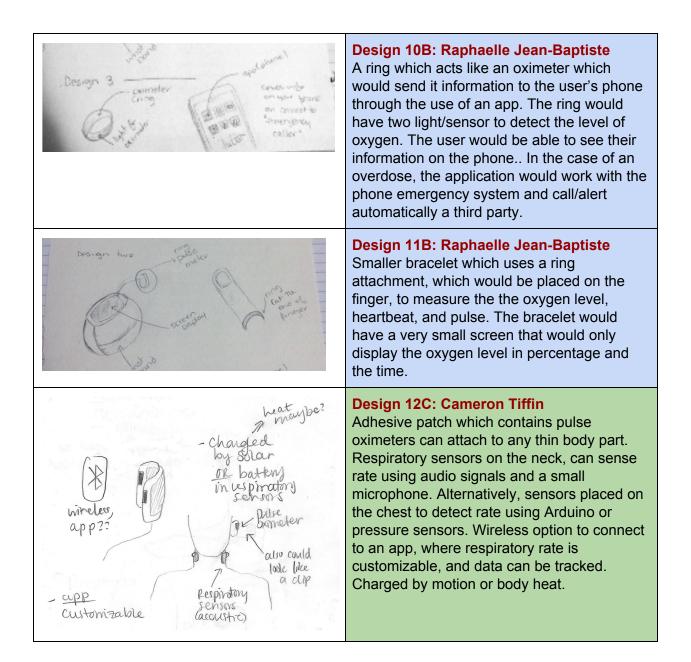
#### Design 8A: Tasha McDonnell

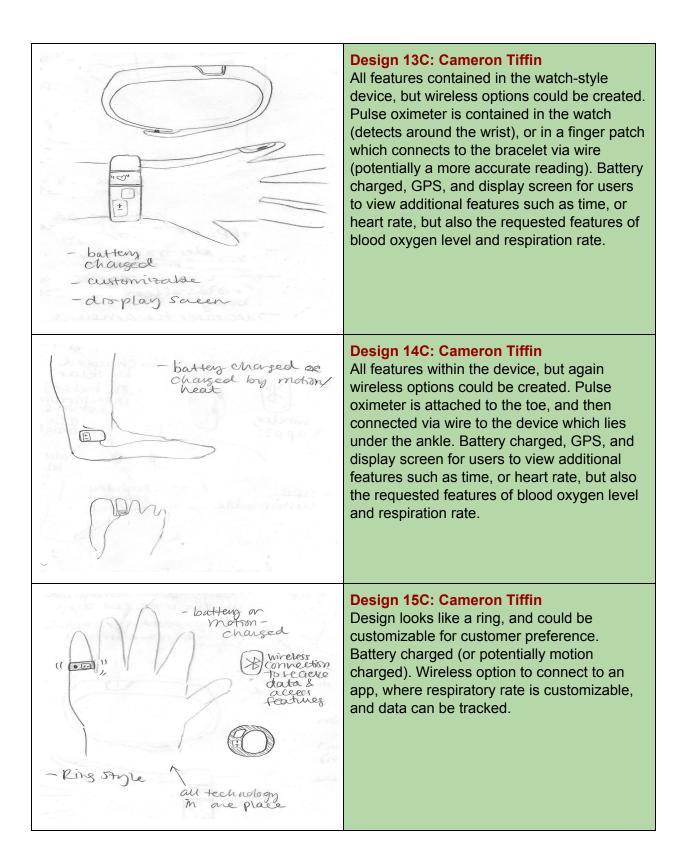
A pulse oximeter and respiratory rate detector is used in this design to ensure accuracy and give help extra time to get to the user. The pulse oximeter is located on the earlobe and connects to the respiratory rate detector and a box holding the technology to send the location and a help alert to a third party. This device would be powered by body heat but would have a battery as a backup.

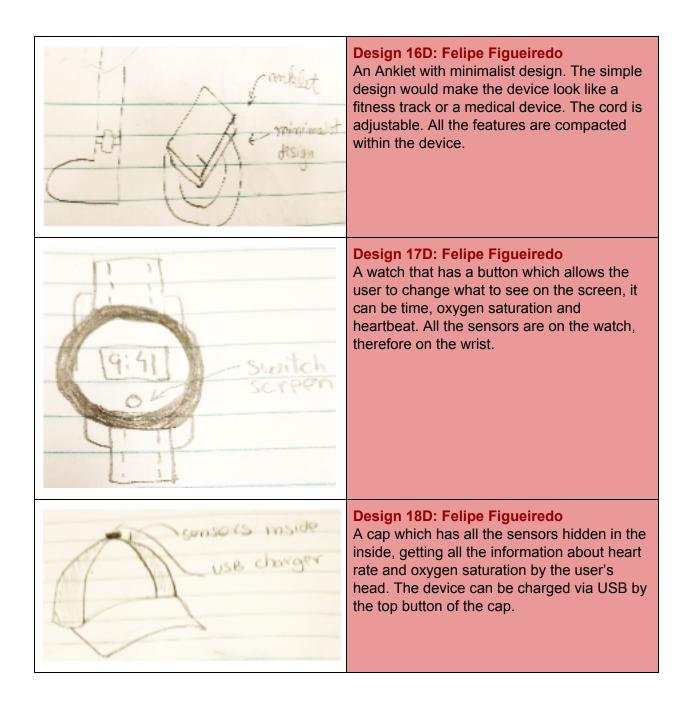


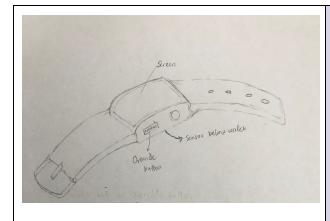
#### Design 9B: Raphaelle Jean-Baptiste

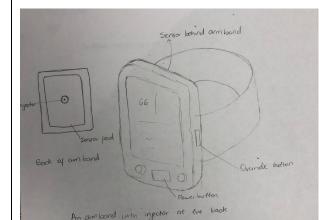
Oximeter in the form of a watch similar to the apple watch in design which has a display screen. On the display screen the user would be able to see their oxygen level heartbeat and pulse in real time. The device would have the ability to alert a third-party. The band of the watch would have to be adjusted correctly to have enough pressure to measure the pulse and oxygen levels. In addition, the back of the band and the back of the watch main component would included the light sensors needed to calculate the oxygen levels









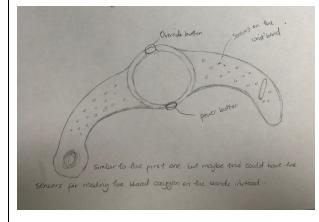


#### **Design 19E: Eze Precious**

Battery charged smartwatch with an override button and an alarm system. This device would make use of sensors located at the back to take measurements that determine the user's pulse oximetry. In the event of an overdose, the watch would be programmed to set off an alarm system and send out the GPS location for emergency assistance. The override button is used in the case of a false alarm and can only be activated if the user is conscious.

#### **Design 20E: Eze Precious**

An armband with sensors and an injector located at the back. This has a large screen to accommodate more measurement readings. Has its own software that monitors the user's pulse oximetry, contains the user's prestored emergency contact and administers naloxone to help extend the timespan for help to arrive. In case of a false alarm, the user can deactivate the system by using the override button



#### **Design 21E: Eze Precious**

Smartwatch with pulse oximetry sensors on the wristband. This would make availability for the addition of more required technology in the device itself. Having the sensors on the band would allow for a larger surface area for taking measurements and could potentially make the device smaller. Device is battery charged, has a GPS tracker, has an alarm system that contacts for emergency care and can be shut down when not needed to extend battery life.

Table 3. Design Ideas

### 3.2 Analysis

Through brainstorming, we were able to generate a number of creative ideas for the design of the device (as seen in Table 3.). However, there is the need to analyze these ideas to be able to develop efficient design solutions. To successfully achieve this, we have evaluated our brainstorm ideas against the design criteria. For instance, it was observed that a few of our ideas would require a phone app. This has it's advantage as it would create the opportunity to make the device as discreet and less expensive as possible. However, on the other hand making the device to be dependent on a phone could be inefficient as this would mean it's dependence on the phone's battery life. Also, considering those who may not have access to a smartphone, this limits the reach of the device in the society. In such a situation, a plausible solution would be to ensure that the necessary phone application can be accessed not only by smartphones. Additionally, we had designs that incorporated the pulse oximeter in a regular day to day sock. For these designs, as much as they would be very discreet and helpful during the winter season to keep the feet warm, it is unlikely that they would be highly utilised during the hot summer periods as people are more inclined to wear sandals and open-toed shoes due to the heat. Another criterion we used to evaluate the sock designs was the cost. Having the pulse oximeter at a position on the sock that lets it come in contact with a toe, while wearing shoes, would require it to be flat enough to avoid the user's discomfort and that device is water resistance to avoid early damage. This water resistance property also applied to the smartwatch design with sensors on the wristband and to the variations of ring designs as they would be located at position of the body that are likely to come in contact with water. The ring design ideas as well as the earring design, the anklet and sock design that were developed were also evaluated to be a bit cost inefficient as they would require small sizes of the inbuilt technology. Nonetheless, having such sizes of the device would ensure important criteria such as being discreet, lightweight and portable are met at a significant level.

From the designs in Table 3, we have combined different ideas to create three new designs. Our first design is a watch/bracelet device. This design will have an oximeter located on the pinky finger (to not interfere with drug use) that will send a signal to the watch/bracelet when the oxygen saturation is at a dangerous level. This design will have a display screen and be connected to an application on your phone that will send the location of the user and a help text alert to a third party. The application will allow you to customize the dangerous oxygen saturation level for each user so that it can still work for users that have any disorders or conditions that give then an abnormal oxygen saturation. This design will also be powered by battery. The second design is an anklet/sock. For this device an oximeter will be embedded into

one of the middle toes of the toe sock (not pinky or big toe). An anklet near the top of the sock will contain all the technology needed to read these measurements, locate the user and send a help alert to a third party. There are a number of benefits for using a toe sock: it will secure the oximeter in place on the toe, it is easy for the user to use (they just have to put on a sock) and it is discrete. This device will require a battery. Our third design idea is a sensor focus device which uses a number of sensors to measure the respiratory rate and oxygen saturation. The oximeter sensor will be located on the back of the earlobe and it will attach to sensors located on both sides of the chest (used to measure respiratory rate) and to a box containing all the technology to send the location and help alert. This device will be powered using body heat and will have a backup battery. There should be enough heat in the chest area to provide power, whereas the hands and feet might not generate enough heat to keep the device constantly powered. These three designs will be described in further detail in the next section.

## 3.3 Refining

Based on the different devices and systems imagined by each team member, as a team, we have settled on three final, fully functioning, designs. The selection of the final global concepts were based on combinations of recurring ideas and concepts as well as their ability to meet the client needs effectively.

Most of these concepts are based on pulse oximeters, which measure most of criterias needed to detect an overdose. Generally, an oximeter would measure the amount of oxygen carried by hemoglobin. *Hemoglobins are proteins found in the red blood cell which carry oxygen*. The pulse oximeter uses the light to measure the saturation of oxygen in the blood. The light is emitted from two light sources (a red and infrared light (in blue)) and passes through a finger to be detected by a light detector (photodetector). Light emitted will be partially absorbed by the finger due to three important factors: the concentration of the light absorbing substance, the length of the path and the hemoglobins. Typically a lower concentration of oxygen will result in a lower absorption and vice-versa. The pulse oximeter measures the amount of red light absorbed in comparison to the blue light in the blood and uses a ratio to work out the amount of oxygen saturation.

The following are analysis of the final three concepts against our design criterias and our selection matrix:

#### 3.3.1 Device/System One

One of the three solutions chosen was an oximeter in the form of a watch. In this solution, the main components of the watch would measure the level of oxygen, respiratory rate, their pulse as well as any other psychological symptoms useful in the detection of an overdose. The user would be able to see their information, which would be displayed on the devices screen, in real time. In addition, the watch would be paired with the customer's smartphone. This will allow the user to customize certain settings, like who they would like to send the alert to in addition to the main third party(ambulances). In the case of an emergency, the application would access the device's bluetooth and cellular abilities to alert a third party ( ambulance, appropriate center, loved one ect...). The application would also allow the user to override the system, in addition to seeing their different patterns of consumption, and pass and present data collected. The watch would be powered by a watch battery, but could also be powered using a normal usb charger. Finally, the watch's band containing the red and infrared light( in blue) would be illuminated and be detected by a light detector which would be located at the back of the watch and would thus send the information through bluetooth to the user's phone in addition to being displayed on the watch's screen.

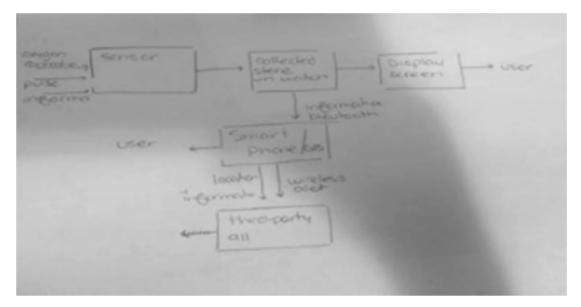


Figure 1. Block Diagram of First Design

#### 3.3.2 Device/System Two

This solution embeds the technology to detect an overdose in a toe sock. This device will be very convenient for users because all they will have to do is put on a sock; they will not have to worry about correctly placing sensors. A pulse oximeter sensor will be placed in the second toe beside the big toe (not in big toe or pinky because they are most important for balance), this will keep the sensor secure to the toe so that the measurements are accurate. We are planning to use MAX30102 and arduino software to create the oximeter. The pulse oximeter will connect to technology located in the ankle that will locate the user and send out an alert for help. The gps technology we hope to use to locate the user is the ublox neo-6m gps module with arduino software. We will then have a bluetooth module send an alert for help and the location of the user to a third party (ambulance or loved one) when the pulse oximeter indicates that the oxygen saturation is below 90 percent. This device will be powered using a lithium ion battery and the battery will last a minimum of one day before it needs to be recharged. This device meets many client needs for the product design; it detects an overdose, is lightweight, doesn't inhibit drug use and is very discrete. Unfortunately, it does not have an override system and isn't customizable. Even though this device does not have an override system we will ensure the oxygen concentration level is measured very accurately (error less than or equal to 5 percent) so that a help alert is only sent when needed. Below is a block diagram of the device which illustrates the process of this design more clearly.

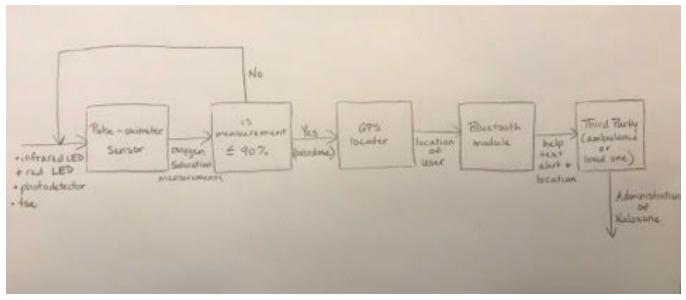


Figure 2. Block Diagram of Second Design

#### 3.3.3 Device/System Three

This design proposal focuses all sensors and detectors on the upper part of the body. We hope to maintain the subtlety of the device, and to prevent any interference with day to day life. Therefore, each sensor resembles something similar to a band-aid, or a simple patch attachment, to avoid large technology on the body. This design does not prevent the user's ability to use drugs, or complete general career/work tasks. The size of the sensors and their durability help to eliminate any concern the user may have about discreteness and blocking daily activities. The simple design attaches a sensor to the upper part of the ear which wraps around like a patch from front to back. This is the pulse-oximeter. When wrapped around the ear, the patch has an infrared/red light on the front side, and the receiving detector on the back. The thinness of the ear will make sure the pulse oximeter works effectively. By extension, this patch technology would also work on the toes or fingers, and therefore could be potentially be repositionable. The most effective method for attachment is if the patch is made with medical-grade sticky adhesive to attach it to the skin. This will prevent it from slipping, so the sensors can do accurate detection. Alternatively, this sensor can work like a clip that can attach to the ear in the same location, improving the mechanism of taking the device on and off. Initially we had decided to have users will also attach a sensor on each side of their chest or neck, which will act as the respiratory sensor. Two practical options to detect respiratory data include audio sensing, which uses a small microphone to detect sound waves, or the Arduino software which can be used to monitor ECG and respiration rate. Being just an asset to the final design, we have decided to compromise the respiratory sensor, as we hope to instead put the focus towards streamlining the device, and ensuring it is as efficient as possible based on our available resources. There are two methods to collect the data and signals from the user and effectively send it off to a third party. One option has a wire attached to the sensor, leading to a larger component on the body which would contain the battery, gps technology, and any other required hardware. We have decided to choose an alternative method, which is wireless and connects via bluetooth to the user's phone. This option could be powered using either a battery, or body heat. We believe having the wireless option allows us to make use of the powerful technology contained in the phone. If developed further, the user could have the ability to track their personal data which will increase their knowledge on

how drug use impacts their bodies. Knowledge can be a factor in user safety.

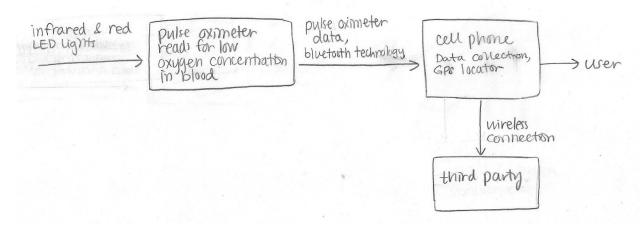


Figure 3. Block Diagram of Third Design

## 3.4 Selected Project/Ideas

After further analysis, we have chosen one global concept which we plan to further develop. This global concept is based on the third device. The third option was chosen for multiple functional reasons as well as advantage above the other designs. This design focuses on sensorial detection of oxygen saturation. Resembling a band-aid, we aim to pair this wireless design as previously mentioned with an app. This allows the user to access their data in real time and see various trends in their physiological data. The application will also facilitate simplify two major functions needed by this device: alert a third party and provide their location.

Living in the information age, research shows that about 96% of people own a cellphone. We would be utilizing the user smartphone cellular abilities to alert the authorities or a third party in case of an emergency. In addition, using the user smartphone will allow us to add another element to this device: customization. The application would provide a sense of personalisation, and the client would be able to add a love one to automatically call in case of an emergency.

Furthermore, this device was chosen because of its ability to be relocated throughout the body. This allows the user more to place the patch where they feel more comfortable and appropriate. In contrast, the first and second system were restricted to a single location so, if the user needed free hands or wear sandals, the devices were not able to accomodate. The patch technology, made with medical-grade sticky adhesive to attach it to the skin, would prevent it from slipping,

so the sensors can send accurate information to the user device. This ability to relocate made it the best option in terms of discreteness and ability to implement in the user's daily. In terms of chargeability, we aim to make this device recharge using body heat, this will allow minimum maintenance from the user perspective. The device would also have a small battery as a way to additional power.

Furthermore, this design satisfies all the criterias listed in Section 2 as well as extra requirements that were not necessary but mentioned by the client. It follows our budget and would be affordable, and easy to use for the project users.

## **Conclusions and Recommendations**

The entire work that was made in other deliverables such as benchmarking, design specification, needs specification and also the client meeting established a path to determine the design for our device. In order to get the conceptual design of our device firstly, we put down all different ideas of design that the group could think of, not worrying about limitations of any kind. Secondly, we determined the three best concepts by seeing which concepts matched the best with the device specifications already established and also the most viable concepts, the concepts that seeing the most realistic to be made by technology-wise and also budget-wise.

After we chose the top three concepts we picked the one that was the best due to having the most advantages when compared to the other two. The design is based on having all sensors and detectors on the upper part of the body. What makes this device stand out from the other two is its practicality. The practically comes from resembling a band-aid, making it easy to put on and also by the fact of having a wireless connection with cell phone, facilitating the process of alerting a third party and providing the user's location.

Our next steps are to figure out how the device will communicate within itself since it has multiple sensors and a wireless cell phone connections and also, methods of making the device the cheapest as possible for the sake of making the device accessible to the most number of opioid users as possible and potentially saving more lives.

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