A7: deciBright

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***Abstract*—For musicians and others who need to track their exposure to noise over time, the deciBright bracelet and accompanying mobile web application is a fast and accurate way of determining and tracking decibel levels.**

***Index Terms*— BLE, Decibels, Microcontroller, Sound Volume, Web Application, LED**

1 INTRODUCTION

According to research recently published in Ear and Hearing, "hearing loss was the most prevalent sensory disorder in the United States" from 1990 to 2019 [9]. Other than obvious uses such as listening to music and friends, our ears are also important to help with balancing, and even mild hearing loss doubles the risk of dementia [26]. Thus, it is important to protect our hearing through minimizing exposure to loud sounds, and becoming more aware of potential risks in the environment. While people can discern some relative volume, the ears are actually not always accurate at determining the "loudness" vs decibel value, because of sensitivity to certain frequencies [33].

Existing decibel meters and phone apps can give more precise information, but they are still disruptive to pull out and check throughout the day. A wearable device would be a convenient visual reminder for long-term tracking of volume levels that will leave your hands free.

Our solution is a LED bracelet that changes color based on the decibels readings of the surroundings. With the accompanying web app, users can view statistics about their exposure over time, modify the sound threshold levels to suit their needs, and customize the colors to make the bracelet a fashionable accessory. From musicians monitoring their practice sessions, to patients collecting data to assess their risk levels, to anyone who wants to be more mindful about their hearing in general, this bracelet enables users to make more informed choices regarding their auditory health.

2 USE-CASE REQUIREMENTS

The intended user of this product is a student or professional in the field of classical music. Musicians often practice or perform music for up to multiple hours a day, and practice rooms are not always set up to have the best acoustics for their needs. Particularly for vocalists, there is a difference between sounds perceived as loud (including quiet sounds with much resonance) and objectively loud sound, which makes it difficult for someone to evaluate the decibel levels of their surroundings. Finally, classical musicians generally do not use in-ear monitors or other digital methods of perceiving feedback about their music; in addition, they need to be able to hear all details of their music. Therefore, hearing protection is particularly important in relation to their music.

2.1 Weight

The weight of our bracelet should not prevent the user from accomplishing tasks, including those that require precise, small motions (like playing an instrument). Therefore, our product should be no heavier than the average smart device that could instead be accompanying these tasks: a smartphone. The approximate maximum weight for a smartphone is 200g [14], so that is also this device's maximum weight.

2.2 Width

In order for our device to be an adequate solution, it must closely mimic the physical attributes of existing items with similar forms. To that effect, the width of this bracelet should be no larger than the largest width commonly offered for a wristwatch: 46mm [31].

2.3 Thickness

Similarly, the bracelet should conform to existing sizing choices for commercial non-electronic bracelets. Our resource on wristwatch sizes [31] describes large bracelet thicknesses as around 9mm; since the plastic insulation on the bracelet slightly extends its size, this requirement is relaxed to be interpreted as a maximum of 12mm.

2.4 Operating Temperature

Since the bracelet will be in contact with the user's skin, we want to eliminate the risk of burns from the product's operating temperature. For our bracelet to be comfortable and safe, we require it to operate at a temperature no higher than 105 degrees, well under the human pain temperature threshold of 107.6 degrees Fahrenheit, found by the NASA Johnson Space Center [32].

2.5 Accuracy

The purpose of our bracelet is to record the sound levels of the environment. Therefore, it needs to accurately record the surrounding noise level. We require the bracelet and app to be within 2 decibels of the actual volume of the room, which is the national standard for sound measurement instruments [20].

2.6 Timeliness

Since our bracelet will be measuring noise changes in the environment, we want our bracelet to capture and respond to the most up to date sounds. Therefore, we require a latency of no more than one second between the detected sound to the web application and the bracelet color display.

2.7 Adjustability

We want our bracelet to fit comfortably on as many wrists as possible. Therefore, we require an adjustable strap of 7-10 inches, which is the standard range of adult bracelet sizes [24].

2.8 Durability

The bracelet should be durable enough to survive a 2.5 feet drop, which is the average height of a standard table [23]. This is to ensure that the bracelet can withstand a certain amount of impact and still function properly.

2.9 Battery Life

The bracelet should have a battery life of at least 4 hours. Initially, we planned for an 8 hour battery life, but with our size requirements, this is no longer feasible. We selected our battery life based on information from a survey we conducted on a dozen CMU music students.

3 ARCHITECTURE AND/OR PRINCIPLE OF OPERATION

For our bracelet, the default colors will be green, yellow, orange, and red. A green bracelet will mean that the current sound levels are not harmful and will cause no damage to the ear. Yellow would represent a decibel level that is not currently harmful, but may cause slight damage if exposed for more than 8 hours. An orange bracelet would represent a decibel reading that would cause hearing damage within one hour. Lastly, a red bracelet would represent a decibel reading that can cause hearing damage almost immediately. These colors and thresholds can be customized on the mobile web application.

Important bracelet hardware components include the microcontroller with built-in BLE module, LEDs, microphones, boost converter, and battery. The battery powers the system through a boost converter. A button in series with the battery-Beetle connection allows the system to be powered on/off. The Beetle microcontroller provides power for the microphones, and connects to the following devices: the LED array via an Arduino analog connection, microphones via an Arduino digital connection, and a mode control button via GPIO. All components except the battery and buttons are mounted on a flex PCB.

Since the bracelet will only display colors that represent a range of decibels, it will be accompanied with a mobile web application that provides further detail about the user's sound environment. The app will be built using React Native and will connect to the bracelet using bluetooth. It will display information such as the current decibel level reading and the maximum decibel reading for the session. Additionally, the app will contain graphs on statistics like sound exposure over time. Lastly, there will be a place on the app to customize the intensity of the LEDs, the color of the bracelet, and the decibel color thresholds.

4 DESIGN REQUIREMENTS

4.1 Operating Temperature

The inclusion of two buttons and a charging port in the device will result in at least one opening for ventilation.

4.2 Accuracy

Over a 5-minute testing period, the difference between the webapp decibel reading and decibel meter reading, read in increments of 1 second, will not exceed 2 dB. For any adjustment value of the tied bracelet, on the plane in which both microphones are situated within the angle created from one microphone to the next, the difference between the direction of maximum volume and the direction of maximum volume indicated on the bracelet will not exceed 60 degrees.

4.3 Timeliness

When a new sound volume is introduced to the setting that meets a threshold level required for the bracelet to change color, the bracelet color will respond by changing color in no more than 1 second.

4.4 Adjustability

Each end of the bracelet will contain a cord made of two strands of polyester string, which will exit the ends of the plastic insulation. The two cords will meet when fed into the adjustable cord lock.

4.5 Durability

After a 2.5-ft fall from rest, the bracelet should be able to operate standard Bluetooth, microphone input, and LED output functions without a noticeable difference in quality or duration.

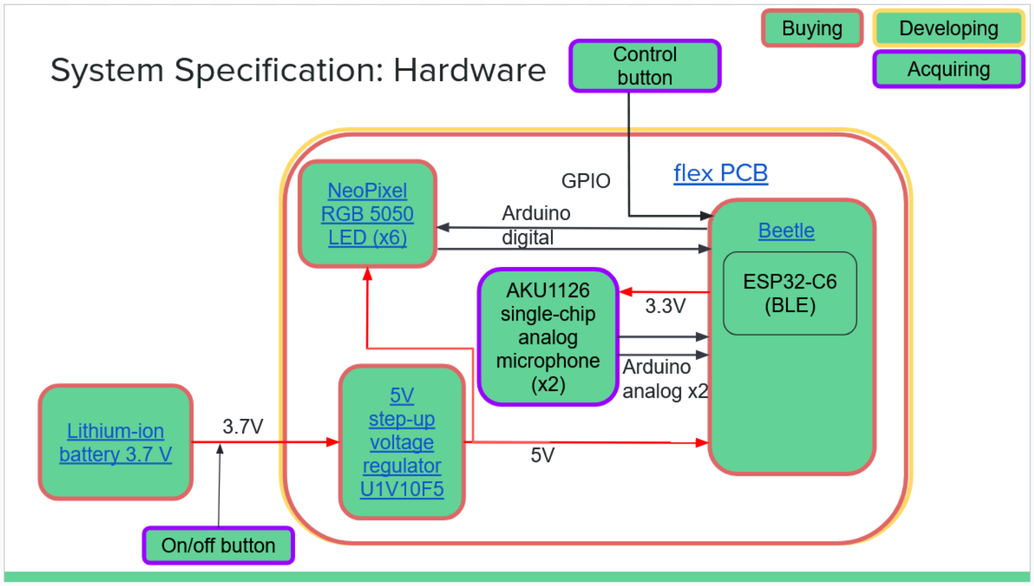

Figure 1: The types of connections between the electronic components are specified.

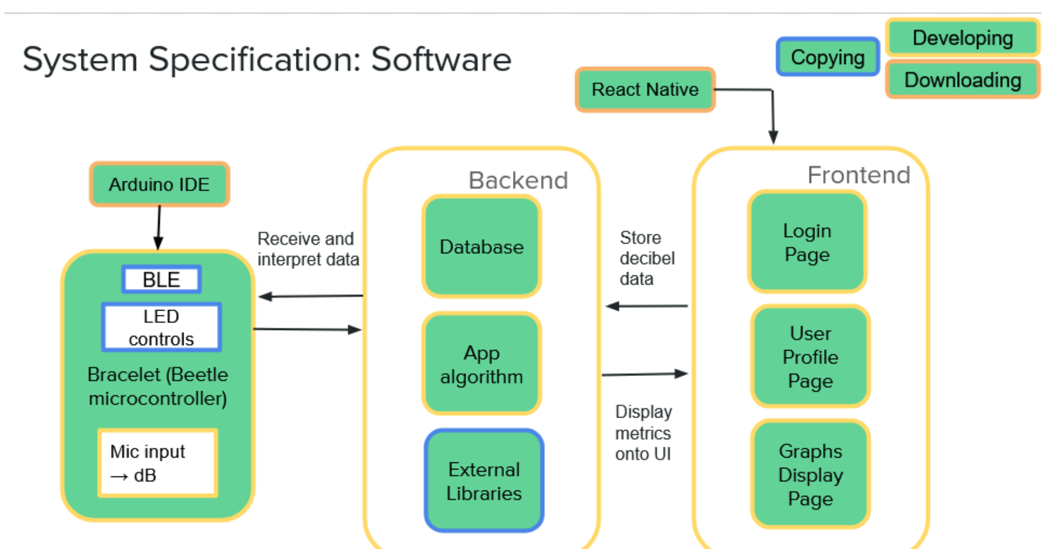

Figure 2: Software system diagram

4.6 Battery Life

After being turned on, the bracelet should maintain a connection with the webapp and update based on both direct input and its surroundings for at least 4 hours.

5 DESIGN TRADE STUDIES

5.1 Hardware

5.1.1 Microcontroller

Several important features needed to be included on a qualifying microcontroller. The microcontroller needed to have a built-in BLE module to make it easier for us to work with (eliminating Gemma [2], Circuit Playground [4], Flora [5], and Trinket [3]), it needed to be able to recharge an attached battery because the bracelet design will not support detaching the internal battery from the internal microcontroller (eliminating Arduino Nano [12]), and it had to be safe to wear (the source needed to show an example of an application in contact with the user). Once microcontrollers that did not fit this profile were eliminated, the remaining can be evaluated for other traits. Size is the most important trait, given that miniaturization is a significant issue for this project; beyond that, the microcontroller needs to support at least one digital output (to an array of LEDs) and at least two other inputs, either both-digital or both-analog (to the microphones). The two remaining candidates are the Adafruit Feather and Beetle with ESP32-C6 BLE; since the Beetle is smaller [15] than the Feather [1], it wins.

5.1.2 Number of LEDs

An equation was constructed to determine how many LEDs the bracelet can support, given the maximum current draw with a given battery life and current draw of other components.

$$((B/H)-(Mics*micA)-(BeetleA))/LEDA = numLEDs \quad (1)$$

Estimated values include: Battery rating: 2500 mAh [18] Number of microphones: 2 is the minimum to establish directionality. Microphone current draw: Since the analog microphone datasheet only provides a current consumption value for no acoustic input, the digital microphone current consumption value of 750 µA is used. [8] Microcontroller current is estimated from the data sheet for the ESP32 C6 Bluetooth module, using the lowest values for data rate and sensitivity [17] as 100 mA. H represents the battery life (in hours). An 8-hour battery life would meet all users' battery life needs. LED current is listed on the Adafruit website [6] as about 18 mA. Therefore, the number of LEDs this device can support, rounded to the next smallest whole number, is ((2500 mAh / 8 hours) - (2 * 0.75 mA) - (100 mA)) / 18 mA = 11 LEDs. However, if the battery is changed to an 850 mAh battery in support of a 4-hour battery life (as requested by users in response to our sizing vs. battery life survey), the result becomes ((850 mAh / 4 hours) - (2 * 0.75 mA) - (100 mA)) / 18 mA = 6 LEDs.

5.1.3 LED arrangement

3 options exist. The first, a zigzag, only requires multiples of 2 for the LED number, but implies that the bracelet is also sensing direction perpendicular to the microphone's direction (by moving forward or back on the bracelet, when the microphones are in the center of the PCB's width). A diamond pattern creates a similar impression. The LED arrangement which creates the fewest constraints is a horizontal line of LEDs; it only requires an even number of LEDs, and all LEDs are in line with the microphones.

5.1.4 Battery life

For a 4-hour battery life, the required mAh for the battery is:

$$B = H*(LEDs*LEDA+Mics*micA+1*BeetleA \quad (2)$$

Assuming 6 LEDs, 2 microphones, and the Beetle microcontroller using BLE, and using the current assumptions from 5.1.2, B = 4 hours * (6 LEDs * 18 mA/LED + 2 mics * 0.75 mA/mic + 1 Beetle BLE * 100 mA/Beetle BLE) = 838 mAh. The next-largest readily available battery is 850 mAh. [19] For a 8-hour battery life, the required mAh for the battery is: B = 8 hours * (6 LEDs * 18 mA/LED + 2 mics * 0.75 mA/mic + 1 Beetle BLE * 100 mA/Beetle BLE) = 1676 mAh. The next-largest battery listed on the Adafruit store is 2000 mAh. [7] Two items which also affect these calculations are the efficiency of the boost converter at roughly 87 percent [29], and the brightness of the LEDs which might, if decreased, decrease the current drawn by the LEDs. While these are not included in the calculations, if the battery life is insufficient, it can be extended by limiting the maximum LED brightness.

5.1.5 Battery configuration

Battery size generally increases as battery life increases. As a result, it is important to choose a configuration of components that takes up the least amount of space in order to meet the sizing requirements. In calculating which configuration should be chosen, values for the 2000 mAh battery [18], 850 mAh battery [19], plastic tubing [28], and plastic wrap [11] are used.

The following equations were used: For plastic wrap insulating both components:
Thickness near PCB = 2*plastic wrap + maximum(battery thickness, PCB thickness)
Thickness below PCB = 2*plastic wrap + battery thickness + PCB thickness
Width next to PCB = 2*plastic wrap + battery width + PCB width
Width below PCB = 2*plastic wrap + maximum(battery width, PCB width)
For plastic tubing insulating the PCB, and plastic wrap insulating the battery:

Sizing (mm)		Bracelet Configuration:		
		Battery next to PCB		Battery below PCB
Thickness, wrap		10		15
Width, wrap		65		39
Thickness, tubing and wrap		10		16.675
Width, tubing and wrap		66.675		40.675

Figure 3: 2000 mAh results for battery configuration

		Battery next to PCB		Battery below PCB
Thickness, wrap		9		14
Width, wrap		63		37
Thickness, tubing and wrap		9.675		15.675
Width, tubing and wrap		64.675		38.675

Figure 4: 850 mAh results for battery configuration

Thickness near PCB = plastic wrap + tubing + maximum(battery thickness, PCB thickness)
Thickness below PCB = plastic wrap + tubing + battery thickness + PCB thickness
Width next to PCB = plastic wrap + tubing + battery width + PCB width
Width below PCB = plastic wrap + tubing + maximum(battery width, PCB width)
Assuming this maximum battery size, no option entirely meets the requirements. However, in a user survey, users preferred a bracelet with a thickness maximum of 12 mm (and a width maximum of 44 mm). Therefore, thickness results above 9 mm but below 12 mm are highlighted in yellow (see 3). Since these results are not sufficient, these equations were recalculated using the 850 mAh battery specifications (see 4). Again, no combination of variables completely meets this requirement; however, the one that comes closest (plastic wrap only, with the battery below the PCB) only exceeds one requirement by 2 mm. For that reason, this configuration is the best for our purposes.

5.2 Software

5.2.1 Web Application

For our web application, we want to create an intuitive, user friendly interface that is easy to navigate. We have chosen mobile development over web development to allow users the ability to conveniently connect to the bracelet at any time. For our mobile application, we want a framework that can be used on both iOS and android platforms. The two options we considered were Flutter and React Native, which are both popular open source software frameworks that allow for seamless cross platform app integration. Ultimately, we chose React Native because its programming language, JavaScript, is the one our group is more familiar with. Additionally, React Native has an abundance of external libraries, such as BLE-PLX that can be used to for bluetooth connection.

5.3 Physical Fabrication

5.3.1 Casing

We knew we needed some sort of casing over the electronics to keep them safe. This casing would need to be transparent (in order to see the lights), flexible (to wrap around the wrist), and as thin as possible (sizing requirements). With these requirements in mind, the material that came to mind was plastic. Two types of plastic shapes could work: tubing or a sheet. See Fig 5.

We planned to buy both of them to test out anyways in case the tube "compress into oval shape" idea didn't work out, and also because we were going to wrap the battery in a plastic pouch anyways; the battery was large enough to have needed 2 separate diameters of tubes which would've been inconvenient, and suffers from the same non-circular dimensionality of being much flatter/wider than it is tall, so a rectangular-shaped bag would fit better.

Later, we calculated that even in the best case scenario, the battery + tubing would be too thick/wide, so the thinner sheet option won.

	Pros	Cons
Tubing	• Won't need to do extra measuring/cutting/gluing assembly if the PCB can fit right through	• Comes in predetermined diameters and thicknesses so hard to find something that will exactly fit as we want ○ Prefer for an oval shape since the PCB is much wider than it is tall; unfortunately that's very hard to find ○ Idea: since plastic is flexible, buy a slightly smaller circular tube and squish it into the shape that the PCB can fit through
Sheet	• Can be thinner than the tubing walls	• Extra measuring/designing to cut out the correct shape and glue things together

Figure 5: Casing Results

5.3.2 Fastener

The two ends of the bracelet need to be attached in a way that is easily adjustable. Common bracelet attachment/adjustment methods include chain & clasp, pulling on both ends (specific knotting technique), and cord lock mechanism. See Fig 6.

Based on the pros/cons, we chose the cord lock, because we value convenience in adjustability, as well as the ends not getting in the way. For different shapes of cord locks, we went with the circular shape because there's more surface area for the button press in comparison to the more narrow, rectangular ones. We also chose small ones to not be too bulky.

5.3.3 Cord

We decided we should use some string to tie the bracelet ends, as well as provide adjustability. Ideally, the string would be strong (don't want the bracelet to snap), resistant to fraying (long-term wear and tear durability), and pliable (to conform well to the shape of the wrist). See Fig 7.

There are many different materials used for bracelets, such as embroidery floss (cotton), polyester cord, and elastic.

There wasn't much competition for this one. Since knots aren't really necessary for the bracelet fastening design and strength, and we value long-term usage, polyester won. The thickness of the cord was based on the cord lock dimensions/recommended thicknesses. I chose the lower end of that for most ease of threading it through, since the thicknesses should all be strong enough.

6 SYSTEM IMPLEMENTATION

6.1 Hardware

Our hardware diagram is displayed in Figure 8. In this diagram, all components are connected to a common ground. An Arduino digital interface is used for the Beetle's connection to the LED array, an Arduino analog interface for the connection between the microphones and the Beetle, and a GPIO connection for the mode control button. RGB values for the LEDs are calculated on the Beetle and sent to the LED array [10]; microphone input signals will be translated into decibel levels using a custom function that processes and interprets the microphone signals. Direction is also calculated on the Beetle by measuring the ratio between each microphone's processed signal.

6.2 Software

Using BLE, the bracelet will send and recieve information from the web application backend. The information the backend recieves, which will contain decibel reading values and sound directionality, will be interpreted using an external library, BLE-PLX. This information will then be displayed on the UI for the user to view.

The mobile application will be built using a React Native framework. The frontend will be written in Javascript. Once the app is open, the user will be brought to a welcome screen, where they will be prompted to either log in to an existing account or sign up. After the authentication process, the user will be brought to a profile screen, which displays the current decibel readings along with other statistics, such as the average sound level, maximum sound level, and total run time for the current session. The app

	Pros	Cons
Chain & clasp	• Pre-built mechanism; just need to attach the ends to bracelet ○ Multiple sizes	• Needs to be precise to hook onto the right chain link => takes more time to adjust • Dangling part of chain could be annoying (could tuck away)
Pulling both ends	• Simple knotting technique • Can be done with just string, so easier to find materials • Very fast/easy to adjust	• Now you have 2 long ends dangling, depending on how far you pull them; the loose ends can be distracting ○ Can tuck away the ends, but that would have to be done twice (since the ends are in opposite directions)
Cord lock	• Pre-built mechanism ○ Multiple sizes • Very fast/easy to adjust	• Still has a long string dangling, but it's easier to tuck away since there's only one end to deal with

Figure 6: Fastener Results

	Pros	Cons
Cotton	• Easy to make tight knots ○ Can combine threads for strength • Pliable	• Fraying threads
Polyester	• Smooth, resistant to fraying (melt the ends) • Pliable • Decently strong	• Might not be able to make as-tight knots because of its smoothness/thickness
Elastic	• No need to attach separate ends of the bracelet with a separate mechanism; could just make it 1 circular piece • Pliable • Strong and fray-proof	• Loses elasticity over time; would have to replace • Not as adjustable; depending on the length it could be pinching or still too loose

Figure 7: Cord Results

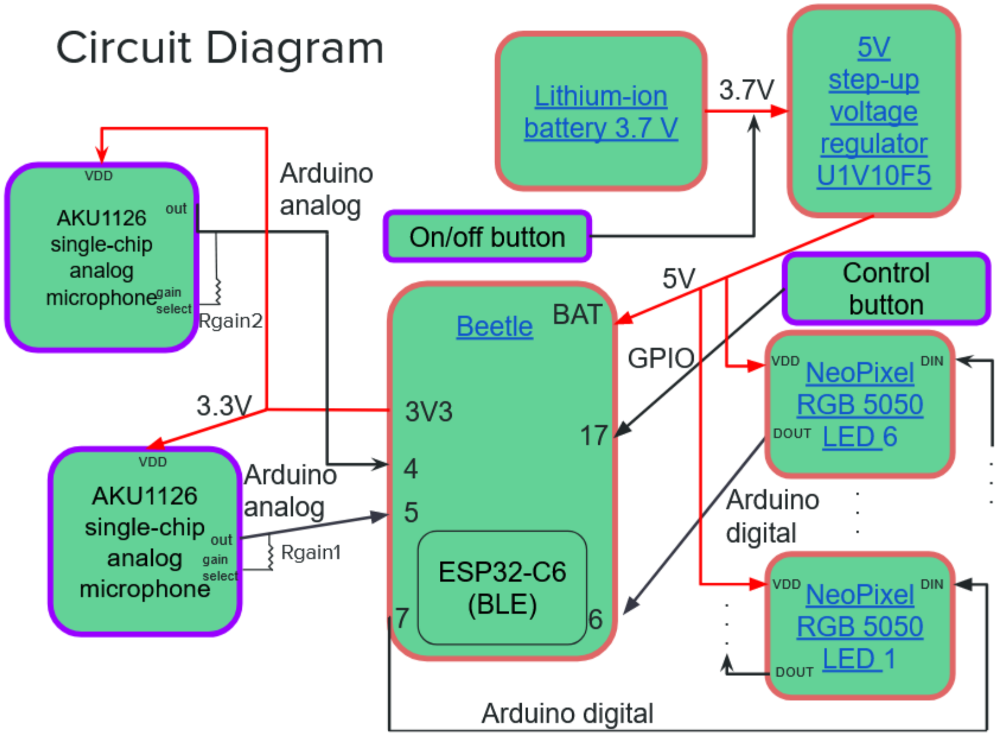

Figure 8: Circuit diagram

will also have a visualizations page that displays the exposed noise level over time in a graph form. Lastly, there will be a settings page where the user can connect their bracelet to Bluetooth, as well as customize the light intensity, threshold levels, and color of the bracelet. A diagram of our software system is shown in Figure 2.

6.3 Physical

The general shape of the casing will be two rectangles that can fit over the PCB, with some extra width to account for the height of the components and bulge of the battery underneath the PCB, and length to make room for string attachment. The battery is already plugged into the PCB, and some polyester cord can be wrapped around the wires for added stability.

One of the rectangles will have cut-outs for where the buttons will go, which will be lightly glued in place for easier access. Then, the long edges of the rectangles can be sealed with hot glue, leaving a gap for the USB charging port. A polyester string with a knot on the end (to help prevent the string from being pulled out) will be sandwiched between each of the shorter ends of the rectangle before they are also glued.

Finally, the free ends of both polyester strings will be threaded through the cord lock, tied into a knot, and briefly melted with fire to prevent the knot from untangling or the ends from fraying.

This process will protect the electronic components from the outside world as much as possible, as well as protecting users from directly contacting the components such as the battery. The adjustability of the bracelet allows many different types of people to wear it, and the materials used are smooth and won't irritate the skin or catch on clothes.

6.4 Tutorials

Tutorials being followed include a BLE tutorial [16], the NeoPixel tutorial [10], and two React Native tutorials [27] [22].

7 TEST & VALIDATION

We will be conducting a series of tests on the different components of our bracelet and web application. This will ensure that all parts of our project meet the requirements we specify in our use case.

7.1 Tests for Physical Design

To verify our bracelet conforms to our physical design requirements, we will use simple measurement tools. For width and thickness, we will be using a ruler to ensure that these dimensions are within our specified requirements. For weight, we will place the fully assembled bracelet on a scale. Additionally, for operating temperature, we will use a temperature sensor while the bracelet is on during the other tests and ensure that the temperature of the bracelet doesn't exceed 105 degrees F. Lastly, we will test the durability of our bracelet by performing a 2.5 ft drop test and making sure the bracelet can still function properly afterwards.

7.2 Tests for Accuracy and Timeliness

To test the accuracy in our bracelet's sound dedication, we will place the bracelet, a speaker, and a verified decibel meter all in a soundproof room. The speaker will be turned to different volumes and we will verify that our bracelet accurately changes color to reflect the speaker's changes. We will also compare our web application decibel readings to the decibel meter to ensure accurate measurement. In addition, the relative angle of the bracelet to the speaker will be changed to ensure that the volume direction is correctly measured and displayed. Finally, these tests will be recorded so we can measure the latency between the speaker sound, bracelet color change, and web application readings.

7.3 Tests for Battery Life and Comfort

Each member of the team will wear the bracelet for 4 hours to test the battery life and user comfort of our finished product. The bracelet will be fully charged in the beginning and we will each record the time when the battery runs out. We will also be testing the responsiveness, adjustability, and comfort of the bracelet in this process.

7.4 Tests for Integration

To test the integration of the hardware and software components of our product, we will test the wireless Bluetooth connection. We will ensure that the bracelet and the web application are sending and receiving the correct data to each other by comparing the LED colors of the bracelet, the microphone values, and the web app decibel readings.

7.5 Tests for Web Application

In order to ensure that our web application works as intended, we will be performing a series of user studies and tests. First, we will test our application's UI by having multiple people download the app and navigate it by themselves. This is to test the ease of use of our application. We will also use this test to ensure that users won't be able to break or crash the site with bad inputs. Furthermore, we will test the security of our app by making sure our authentication works as intended. Only a correct username and password will allow a user to view their personal profile and history. Also, we will test our web app's ability to correctly store and output the noise level data into statistics and graphs for the user to view. Lastly, our web application will have adjustable settings for color, sound threshold, and light intensity customizations. In order to test these functions, we will be switching between different combinations of these features to ensure that these customizations are accurately reflected on our bracelet.

8 PROJECT MANAGEMENT

8.1 Schedule

According to current estimates, software will be finished on March 16th and the physical instantiation of the bracelet (material and hardware) will be finished on March 17th. We intend to finish testing for individual characteristics such as timeliness, accuracy, and operating temperature on March 30th; data transmission tests and integration (wearing) tests run from April 6th through April 20th.

The schedule is shown in Fig. 9.

8.2 Team Member Responsibilities

Each member of the team will be responsible for a specific section of the project. They will also be responsible for testing their individual components.

Lucy Chen will be primarily responsible for the creation of the web application UI and design. She will also code the backend of the app, which includes implementing modules for data storage and BLE communication with the bracelet.

Katherine Sabak will be primarily responsible for the signal processing and hardware of the bracelet. This entails electronic prototyping, microphone signal processing, and helping with the bluetooth connection.

Freda Su will be primarily responsible for the physical design of the bracelet, which includes manufacturing the bracelet casing and setting up the LED signals. She will also work on the Arduino code and PCB fabrication for the hardware of the bracelet.

All team members will be involved in the hardware component selection process as well as the integration testing of our final product.

8.3 Bill of Materials and Budget

Our budget is 600 dollars, and the total cost breakdown for 1 bracelet is shown in Table 1.

8.4 Risk Mitigation Plans

One of the greatest risks that our device suffers from is fragility. With many small components, any unintended contact or force could break internal components. We are mitigating this risk through external protection of the physical components. Plastic wrap will cover the PCB, and its ends will be sealed with hot glue. Plastic wrap will also cover the battery, so that the entire bracelet will have a coating protecting both the user (electrical insulation) and the components.

Table 1: Bill of materials

Description	Model #	Manufacturer	Quantity	Cost @	Total
Beetle ESP-32 C6	DFR1117	DFRobot	1	$4.90	$4.90
NeoPixel RGB 5050 LED w/ Integr. Driver Chip (100)	3094	Adafruit	1	$29.95	$29.95
Pololu 5V Step-Up Voltage Regulator	2564	Pololu	1	$5.95	$5.95
BATTERY LITH-ION 3.7V 850MAH	1568-1495-ND	SparkFun	1	$10.95	$10.95
INSPIRELLE 3mm Black Satin Cord, 50 yd spool	-	Inspirelle	1	$9.99	$9.99
NECAUX Custom 12x16 Inch Clear Desk Cover Protector	-	NECAUX	1	$10.99	$10.99
Adj. Cord Lock Round Ball Style Single Hole End Toggle	2135-4001	SpecialistID	1	$0.19	$0.19
PCB w/ solder mask	-	JLCPCB	1	$21.72	$21.72
Buttons	-	IDeATe resources	2	$0.00	$0.00
AKU1126 Single-Chip Analog Microphone	AKU1126	Akustica	2	$0.00	$0.00
Mic gain and LED resistors (varies, under 1000 ohms)	-	personal supply	4	$0.00	$0.00
Decoupling capacitor	-	personal supply	1	$0.00	$0.00
					$94.64

9 RELATED WORK

Related work includes CyberJewelry [13], GEMMA [2], Chameleon [30], Fitbit [21], and LED Jewelry [25].

10 SUMMARY

Our light-up bracelet offers a more convenient way to learn about the wearer's exposure to noise levels over time, giving them the knowledge they need to make more informed decisions about their health. Our biggest challenge will probably all be related to the form factor of fitting all the components in a bracelet-sized container, while maintaining a long enough battery life. Specifically, the delicacy of small components and potential breakage means we factored in buying spare parts into our budget (which can also help to parallelize testing in the future). We also expect in code debugging and verification tests to take some time, so we're trying to keep on track with our schedule so we'll have buffer time in case anything goes wrong.

Glossary of Acronyms

- BLE: Bluetooth Low-Energy
- LED: Light-Emitting Diode
- PCB: Printed Circuit Board

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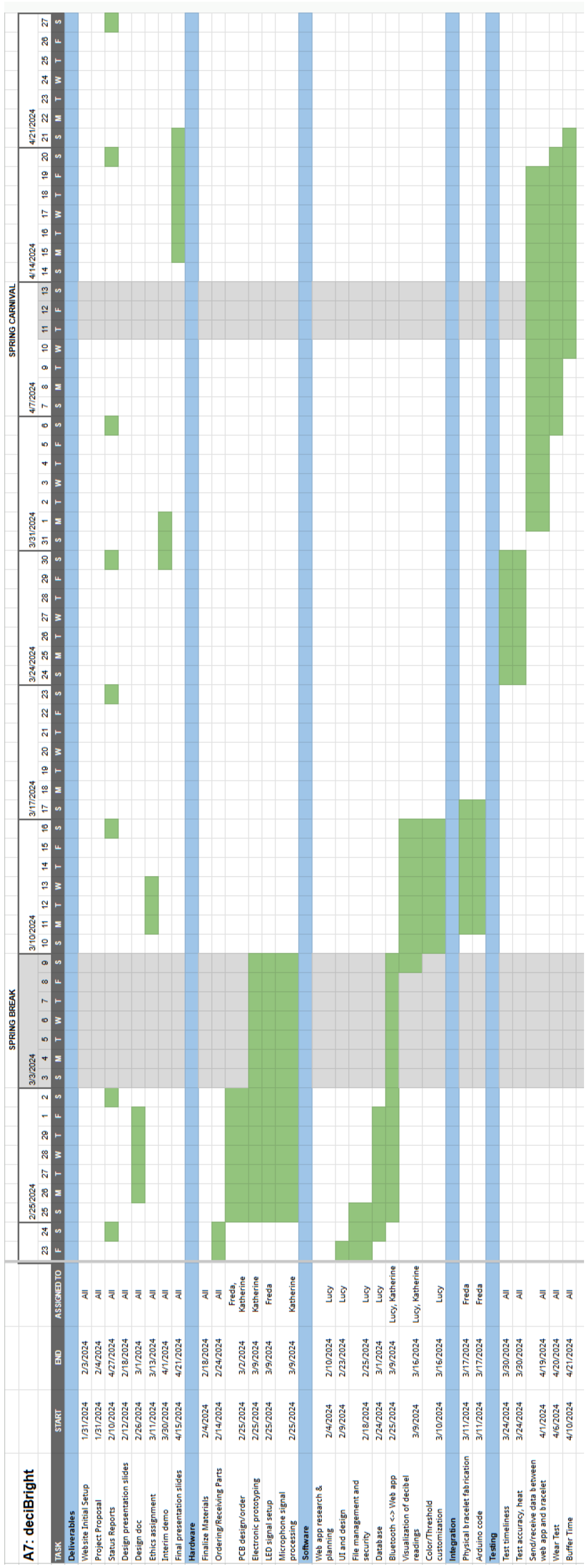

Figure 9: Gantt Chart