“A cost-effective, self-powered, and reliable location-monitoring device for tracking loved ones”

Team Lost and Found, 2019-20 Season

THE THIRD EYE

Search and Rescue Reimagined

According to the National Crime Information Center (NCIC), over 600,000 US persons went missing in 2018 costing nearly $2B in search and rescue, with our home state Oregon ranking third in the country. We have built a wearable and self-charging device (The Third Eye) that allows families to monitor their loved ones without excessive premiums or recurring expenses.

We are affiliated with

RoboRink
Inspired by Intelligence

http://www.stem4girls.org/roborink/

Special thanks to our team advisor and to our parents
for their support throughout the season

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Abstract

According to the National Crime Information Center (NCIC), over 600,000 US persons went missing in 2018 costing nearly $2B in search and rescue, with our home state Oregon ranking third in the country [16]. An NCIC guideline describes a missing person as those who have gone missing “due to personal choice, an abduction, foul play, a mental or physical disability, or a natural catastrophe, among other reasons.” Since the popularization of the handheld smartphone, many missing people have been located by the use of installations and softwares on these devices that can track the victim [11]. However, in many cases, smartphones and smartwatches are not available, especially in cases of abduction and natural disasters. The most prevalent modern solution to this issue is softwares built into the operating systems of many smartphones. An example of this in Apple devices is Find My, a novel example of GPS technology used in this way [13]. However, due to the often lack of smart devices in such situations, our team set out to create a self-powered, GPS-monitored footwear insole to help solve this issue. Our original design was based only around the self-powered aspect of the design, focusing on a group of materials possessing a property called piezoelectricity (a material property that converts mechanical energy into usable electrical energy) [1]. In our second design, we connected a GPS transmitter to the device and focused on making the design more practical in real-life use. In the future, we hope to connect the data through the use of an application on family and friends’ mobile devices that shares the data real-time, and can possibly alert authorities with the push of a button.

Resources: IRB Form

*eCYBERMISSION Survey Approval Form***

eCYBERMISSION team name: Lost and Found

Team Advisor name: Ananth Sankaranarayanan

Team Advisor email: sanapdx@gmail.com

Team Advisor phone: 503-780-5874

Student usernames: Shreyas Ananth, Kapil Kakodkar, Rishab Madhusudhan, Teju Datla

School name: RoboRink Stoller Middle School

School address: RoboRink 15160 NW Laidlaw Rd, Portland, OR 97229

Describe the survey your team will conduct:

According to the National Crime Information Center (NCIC), over 600,000 US persons were missing in 2018 costing nearly $2B in search and rescue and our home state Oregon ranks third in the country. We have built a wearable and self-charging device (The Third Eye) that allows families to monitor their loved ones without excessive premiums or recurring expenses. We would like to survey to record prices members would be willing to pay for this device.

Describe the participants you plan to distribute your survey to:

Community parents, friends and families on social media such as facebook.

Project approved by school administration?

- [x] Yes
- [ ] No

Approved by: Nixon Xavier (RoboRink)

Title: Robo Rink / STEM4GIRLS non-profit co-founder

Date approved: 02/17/2020

Signature, School Administrator: X 2/18/2020

*Please have form completed, signed and dated BEFORE surveys are administered.

**As of August 2017, an IRB approval form (below) must be completed for all surveys as well as the information requested above.

Team Collaboration

How was your team formed? Was your team assigned or did you choose to work with each other?:

Team Formation

We are the team Lost and Found. Our team was formed last year as the Stumptown Glucobots. We originally chose to work together as we were all interested in participating in the eCYBERMISSION competition. We also all went to the same school, so it was easier for us to communicate and work well together. We had so much fun working together last year that we chose to participate as 7th graders this season. This year, we also added a new member to our team. We thought that she would be a perfect fit because she also goes to the same school and we have worked with one another in other competitions like FLL (First Lego League) and OBOB (Oregon Battle of the Books). Our team advisor introduced eCYBERMISSION as part of RoboRink, a non-profit based in Portland, Oregon that our team was connected to . We are a four-member team and we all go to the same middle school in Portland. We also have several common interests such as science, technology, robotics, and programming. Two of us have been together since kindergarten and have participated in FLL robotics programs for the past 5 years. As the three of us have known each other and fortunate to be attending the same middle school, we really work well with each other while at school as well as outside of school on weekends. We adopted and practiced several core values, some of them derived from FLL. We weren't assigned to be a team, we just chose to be one because of our common interests.

Provide a detailed description of each team member's responsibilities and jobs during your work on the Mission Folder:

Roles & Responsibilities

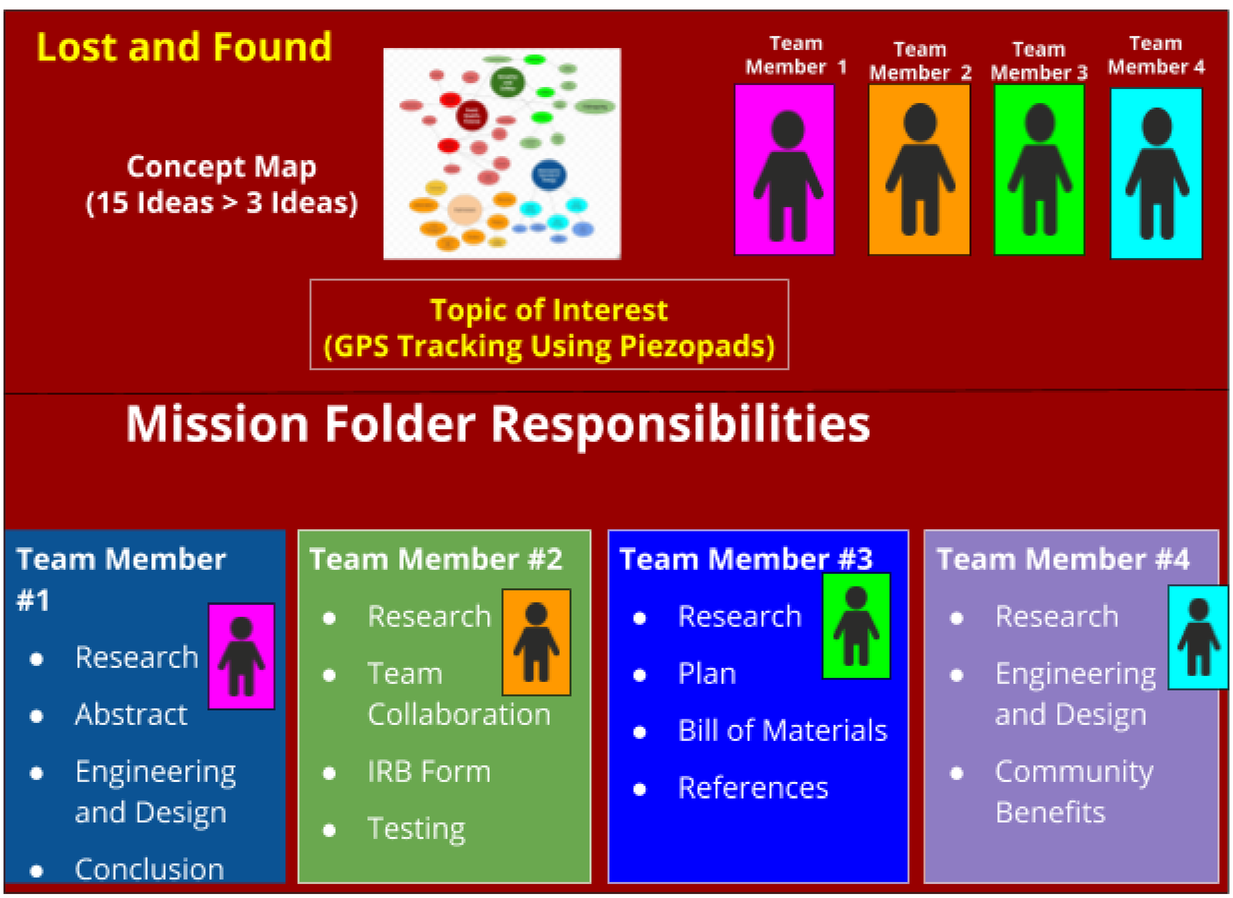
When we began this season, all four of us explored and researched fifteen different issues and identified the top three areas that have the maximum benefits to our communities locally and worldwide. Every meeting, each of us presented two research areas to the rest of the team. Once the idea was presented, we all provided one positive and critique feedback. Based on various factors, such as the magnitude of the problem, impact on the community, cost, and accuracy of existing solutions, we narrowed down to the top three ideas to further research and identify one problem statement. We held each other accountable for completing our respective sections in the mission folder, while at the same time we reviewed each other's work and provided feedback. We also helped each other when any one of us was stuck. At the end of each meeting, we followed the Rose, Bud, Thorn analogy to discuss what we accomplished, homework for the next meeting, and areas for improvement. We split up the mission folder responsibilities among the three of us as follows:

Team Member # 1: Research, Abstract, Engineering and Design, Conclusion

Team Member #2: Research, Team Collaboration, IRB Form, Testing

Team Member #3: Research, Plan, Bill of Materials, References

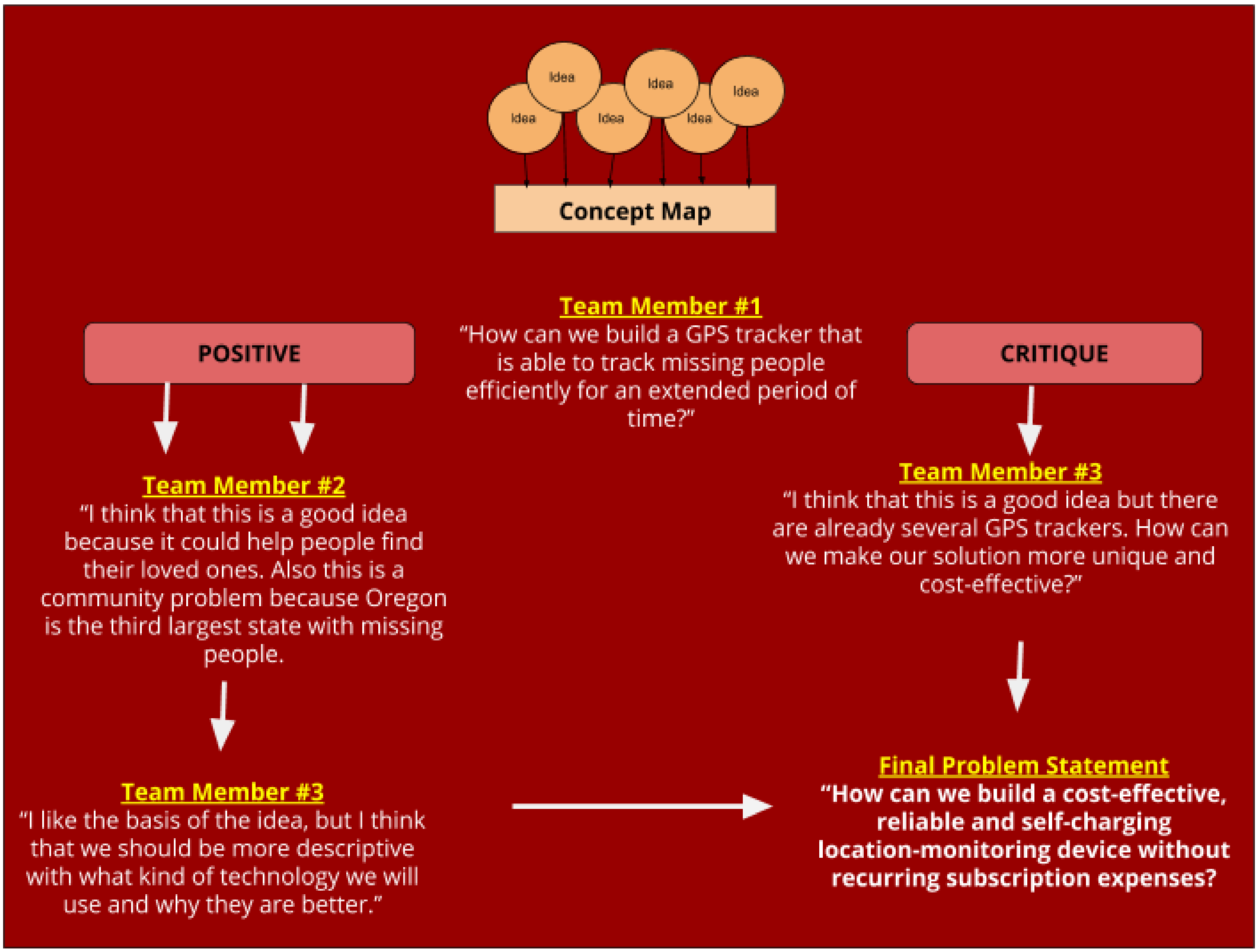
Team Member # 4: Research, Engineering, and Design, Community Benefits



Did your team face any problems working together? If so, how did you solve them? If not, why do you think you were able to work together so well?:

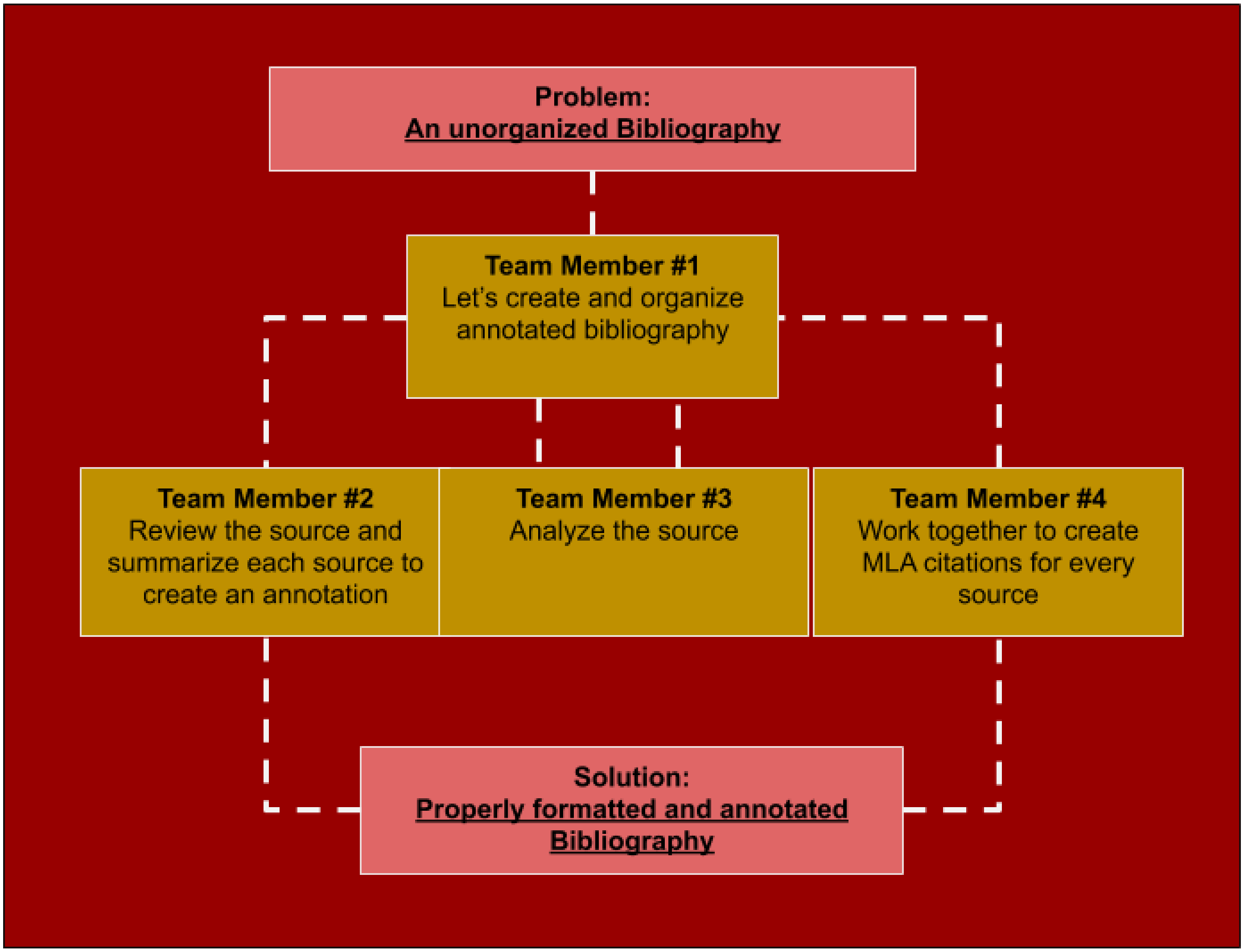
Operating Model

When we formed the team, we originally faced some challenges in keeping track of our progress and updating each other with our research. We adopted a Google team shared drive to keep track of each other's work and stay organized throughout the season. By constructively critiquing each other's ideas, we were able to work together well as one team to achieve our goals.



We shared our research work with each other between our meetings and its benefits to the community. We would collect as many resources as possible and we would decide if that source was usable. Most of the time we would scrap it for two main reasons. One, because the source was unreliable and two was because it was not something that helped the community.

While each of us had specific focus areas for the mission folder mapped to our areas of interest, we learned from each other based on our research work and challenged each other to perform at our very best. For example, for every source that we used in our research, we had to follow the MLA format for the reference section in the mission folder. Team Member #1 took the responsibility of holding all of us accountable for following the MLA standard, so overall as a team we met all our objectives.



What were some possible advantages to working together as a team on this project? How would working as individuals have made this project more difficult?:

Importance of Teamwork

Our coach taught us, “teamwork is the ability to work together toward a common vision”. We observed several advantages of working together as a team. As a team, we were able to learn a lot more new topics than as individuals. We shared what we learned with each other in team meetings, and while each of us had specific roles and responsibilities, we also helped each other when we were not able to make progress. Working as individuals, each of us would have had to do at least three times more work in conducting research, building and testing our prototype, meeting with experts to gather feedback and in completing mission folder requirements.

Our Core Values

We are a Team!

We learn from each other!

What we learn is more important than what we win!

We positively influence our communities!

We have fun!

Our teamwork was very effective in many ways. We gave each other a lot of feedback, learned from each other, finished all the work by the due dates we set for ourselves and had fun. For example, our brainstorming process involved the use of a whiteboard to produce concept maps and write ideas that we thought affected our community. We all split the fifteen total relevant ideas and did a page long research segment on each topic. At our next meeting, we went over what we learned from the topic and any feedback or related queries we had with the topic. We used the provided resources to develop team-building skills which we used to conduct research, solve arguments and make important decisions.

We also worked together to edit and review the others' work which provided a more polished final product.

After working out the details of our problem statement and coming up with a rough idea for our solution, we decided to split up the work. Although our research and designing were handled individually, we worked as a team to assist each other throughout the way, for example, taking on someone's work with them if they were stuck in an area that was not their core expertise.

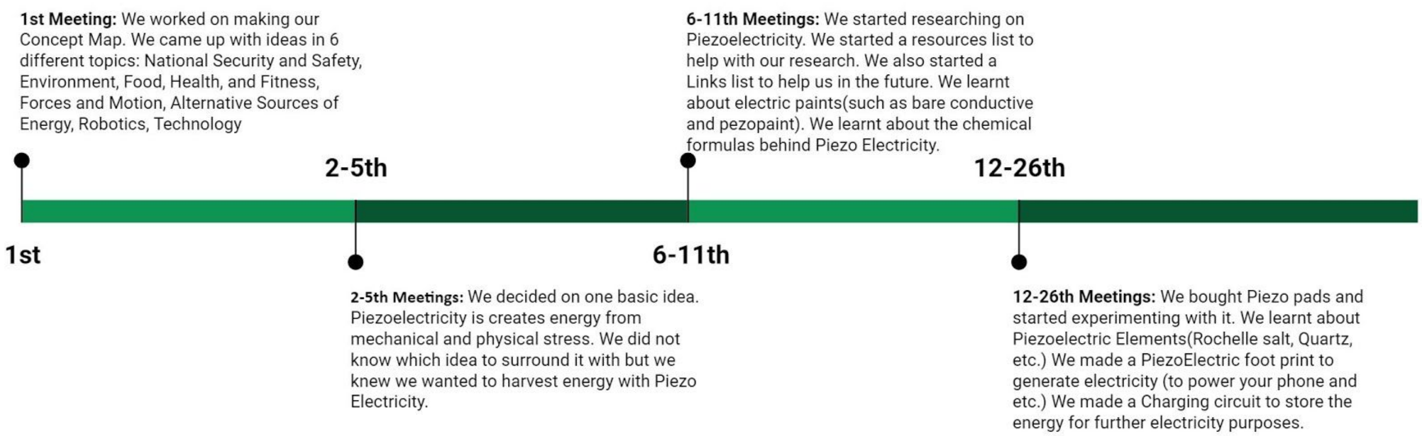
Volunteering

We volunteered at the Oregon Homeless Shelter and prepared food for 200 homeless people in our community. This has taught us to appreciate what we have and give it back to supporting our communities. When we began the season, we explored nearly twenty ideas for applying harvested energy from human body movements, and chose to work on the project articulated in this document. Many of us were interested in developing a way to improve the lives of homeless people due to the emotional connection we had with that demographic. Ultimately, we decided to move on from that topic and focus on a more relevant issue in our communities.

Plan

Timeline

- Week 1: Team Kick-Off
- Week 2: Create a Concept Map, watch the Three videos at Ecybermission.com
- Week 3: Select A Topic, Choose A Community, and found a problem
- Week 4: Research and Expert Meeting and Interviews
- Week 5: Criteria and Constraints
- Week 6: Research The Prototype
- Week 7: Plan Prototype
- Week 8-End: Prototype/Mission Folder and Data Collection and Conclusion



Meeting Logs

week	Goal:	Accomplishment:
9/8	Team Kick off	Generated more than 15 Ideas!
9/16	Create a concept map, Watch 3 videos and do the worksheets for the videos	Went down to 3 ideas
9/22	Select a Topic	We narrowed down to top 3: Homelessness, Harvesting Energy, Kidnapping
	Find a Problem	Still Researching (3 Topics)
10/6	Select Our Community	Still Researching (3 Topics)
10/13	Research	Selected Topic: Kidnapping (With Piezo Electricity)
10/20	Expert Meeting + Interviews	Went in-depth on aspects of Piezo Electricity
10/27	Criteria + Constraints	Went and Researched on Conductive elements for Piezo Electricity

11/3	Plan Prototypes	Made Experiments Using Piezo
11/10	Every Week Until End: Prototypes	Started Our Foot-Print(Piezo
11/17	Prototypes	NO MEETING
11/21	EARLY REGISTRATION ENDS. LAST CHANCE TO RECEIVE FREE STEM KIT	NO MEETING
11/24	Prototypes + Mission Folder	Sorting Piezo Pads to put on the Foot-Print
12/1	Prototypes + Mission Folder	Started Soldering the Wires Together
12/9	Prototypes + Mission Folder	Hot Glued the Piezo-Plates To the FootPrint
12/15	Prototypes + Mission Folder	Asked Engineering Expert, Stalin Jeyasingh (Intel Principal Engineer) To help us wire The Piezo Electricity plates with a breadboard.
/	Prototypes + Mission Folder	NO MEETING
12/29	LAST CHANCE TO FINALIZE TEAM	NO MEETING
1/5	Prototypes + Mission Folder	NO MEETING
1/12	Prototypes + Mission Folder	NO MEETING
1/19	Prototypes + Mission Folder	Asked Engineering Expert, Stalin Jeyasingh (Intel Principal Engineer) To help us wire The Piezo Electricity plates with a breadboard.
1/26	Prototypes + Mission Folder	As we tested the footprint, we noticed that it would not store the energy, so we put capacitors to store the energy for later use.
2/2	Prototypes + Mission Folder	We found out about a GPS device to use for the kidnapping element part of it. It was a Bluetooth GPS monitor that you have to code. (Researching Existing Solutions)
2/9	Prototypes + Mission Folder	We Bought the Device
2/16	Prototypes + Mission Folder	Started Coding the Device getting (Longitude and Latitude) for getting location.
2/23	Prototypes + Mission Folder	Started Putting the Coordinates into google maps to find the exact place they are at no time.
2/26	MISSION FOLDER SUBMISSION DEADLINE	
3/2	Prototypes + Mission Folder	
3/9	Prototypes + Mission Folder	
3/13	VIRTUAL JUDGING STARTS	
3/16	Prototypes + Mission Folder	
3/23	Prototypes + Mission Folder	
3/27	VIRTUAL JUDGING ENDS	

Concept Map Creation

Possible Applications of Piezoelectricity:

Harvesting	**Applications**
Shoes	• LED Shoes, • Phone charging • Tie Shoelaces
Treadmill	• Power the Gym/house • Charging a phone • Giving a cooling effect
Basketball Court	• Power Lights • Power The NBA shot clocks • Power Microphones • Power Music(Sound at the beginning of games)
Gloves	• Giving a cooling effect • Powering an airbag
Knee Pad	• Power airbag
Socks	• Charge a cell phone • Light up shoes
Transportation	• Power Lights • Power the Charging Stations • Power Computers • Power the Flight/Train Screens
Missing People	• Charge GPS tracker
Sidewalks	• Power Street Lights • Power Traffic Lights
Arm Sleeve	• Power lights on a backpack • Charge phone • Power GPS • Power heater
Backpack	• Power Cell phones • Power Flashlights
Notebook/Pen	• Power the Pen Lights • https://getrocketbook.com/pages/how-it-works
Vest breathing electric thing	• Heating blankets • Powering lights • Cell phone charger

Expert Discussions (Mr. Kevin Johnson From Meggitt)

Meggitt Piezo Paint - Flexible Printed Ceramics

Dear Kevin -

We are the “Team Lost & Found” from seventh grade at Stoller Middle School in Portland, Oregon, participating in the U.S Army-sponsored eCYBERMISSION science competition. According to the National Crime Information Center (NCIC), over 600,000 US persons went missing in 2018 costing nearly $2B in search and rescue, with our home state Oregon ranking third in the country. We have built a wearable and self-charging device (The Third Eye) that allows families to monitor their loved ones without excessive premiums or recurring expenses. To solve this we wanted to research ways to harvest electricity from human body movements and apply the generated energy to charge the device.

We have been researching piezoelectric materials and have built a prototype to harvest enough energy to fully charge a cell phone on a daily basis from walking. We realized the piezo pads we used are fragile and may not last for more than a few months. Additionally, we are planning to create several products including shoe insoles, knee sleeves, energy mats for doorsteps and treadmills, and hence we are looking for flexible piezo materials. While researching online we grew curious about your PiezoPaint concept and would like to learn more so we can understand how we can apply such technology in our project for better durability.

We would really appreciate it if you can introduce us to someone on your team who can talk or meet with us for 15-30 minutes, so we can share our ideas and get their feedback on how piezo paint can help us.

Thank you in advance!

Shreyas, Kapil, Teju, Rishab

Expert Meeting (Mr.Stalin Jeyasingh, PE, Intel)

Stalin Jeyasingh is a Senior Principal Engineer at Intel Corporation. He helped us with the wiring for our footprint. He taught us about alternating and direct current. He taught us how to use a multimeter. After we were having struggles and difficulty to store the volts of energy we produced from the piezo pads. He taught us a way to store energy using capacitors. Even though it would not be able to store it for a long time, because we did not have a battery at the time. To conclude he taught us how to wire and conduct electricity with the movement of your body.

Portland Sheriff's Office Search and Rescue

Nike Adapt (Self-Lacing Shoes)

Dear Nathan -

We are the “Team Lost & Found” from seventh grade at Stoller Middle School in Portland, Oregon, participating in the U.S Army-sponsored eCYBERMISSION science competition. According to the National Crime Information Center (NCIC), over 600,000 US persons went missing in 2018 costing nearly $2B in search and rescue, with our home state Oregon ranking third in the country. We have built a wearable and self-charging device (The Third Eye) that allows families to monitor their loved ones without excessive premiums or recurring expenses. To solve this we wanted to research ways to harvest electricity from human body movements and apply the generated energy to charge the device.

We have been researching piezoelectric materials and have built a prototype to harvest enough energy to fully charge a cell phone on a daily basis from walking. We realized that Nike has an Adapt shoe brand that can self-lace and it also can be wirelessly charged. We would like to share our ideas with your team and seek feedback and guidance.

We would really appreciate it if you can introduce us to someone on your team who can talk or meet with us for 15-30 minutes, so we can share our ideas and get their feedback on how your shoes operate and how the wiring was.

Thank you in advance!

Shreyas, Kapil, Teju, Rishab

3D Printing Expert (Shashi Jain, Product Strategist)

Shashi Jain taught us details on various 3D CAD design software tools design principles. We used those learnings to develop 3D design models for our prototypes. We also presented our project idea to him and incorporated his feedback in designing a compact solution that can be water-proof.

Engineering Design

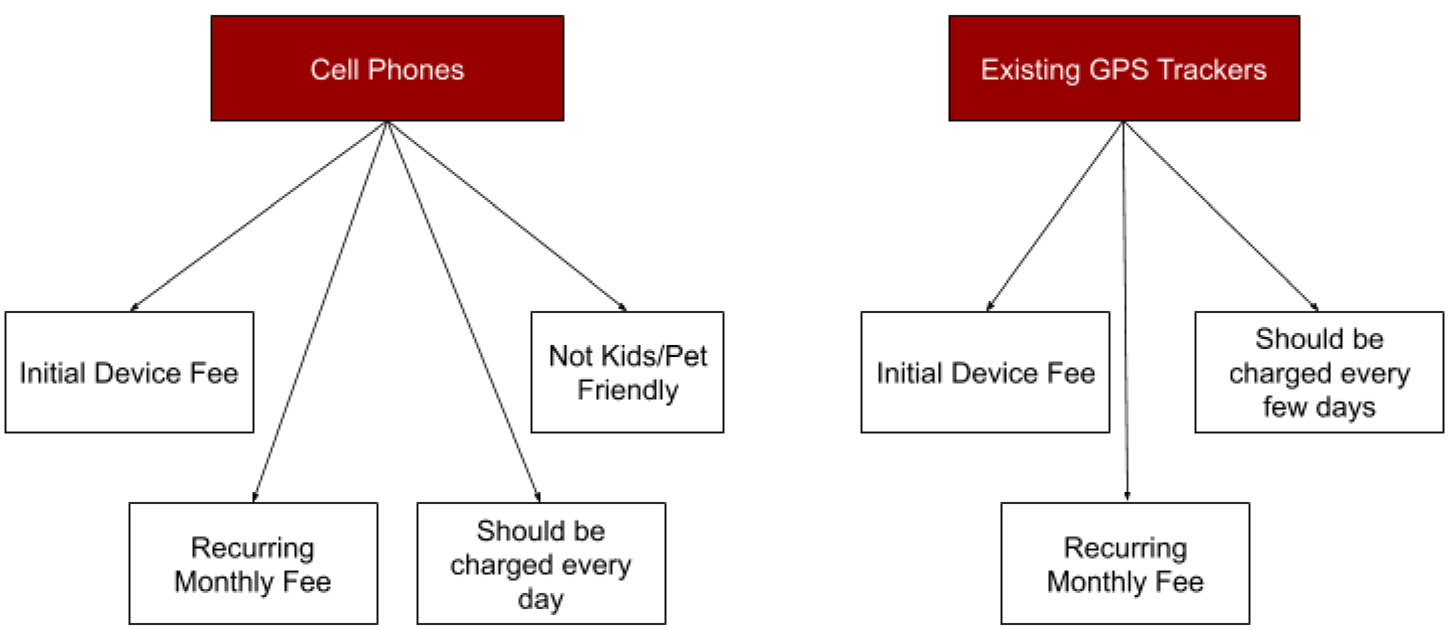
Problem Statement

<u>What problem in your community will your team attempt to solve using the engineering design process?:</u>

Problem

According to a 2018 National Crime Information Center (NCIC) database, there were over 600,000 missing people cases in the United States during that year [16]. A 2018 ABC article on the subject states that the average missing person case is usually a result of cell phones and other electronic trackable devices being left at home. Missing persons are usually suicidal or are in life-threatening conditions, and every minute counts following their disappearance [16]. Currently, one of the most useful ways of assistance to authorities is the AMBER Alert, a technology developed in the early 2000s to help locate missing people and minors as quickly as possible through alerts on smart devices in the area. While this system is effective, established authorities must have enough evidence to determine that the victim is truly missing, and this time can be anywhere from a few days to multiple months depending on the circumstances. Thus, a more effective way of locating people was necessary. Upon the advent and popularization of the smartphone and other smart devices, applications such as Find My were built into the smartphone operating systems to help people and authorities locate lost and missing mobile phone users. The setback of this system of tracking is that in many cases, such devices are not present with the missing person. Current solutions do exist, such as multiple proposed GPS systems, commonly used in pets or tracking other forms of wildlife. While these are effective in tracking, they often require external charging, difficult attachment, and unnecessary fees. Power banks in these devices only have a lifespan of seven days, and thus are not effective for long term use. Our team sought to improve on these existing devices by making them convenient and efficient for missing people's use.

Problem Statement: What can be done to cost-effectively and reliably track missing loved ones?



Research

Explain what you learned from your research. What did you find out about your problem that you didn't know before? What kinds of possible solutions already exist? Be sure to put this in your OWN words, do not just copy and paste information. Also, be sure to cite your sources:

In our research, we found that the NCIC recognizes five types of missing children; runaways, abduction by a third person, national or international parent abduction, missing unaccompanied migrant minors, and lost or injured missing children [16]. Roughly 91% of all missing children cases are classified as runaways, and usually, these children run away as a result of at-home abuse or severe depression [16]. There are many solutions designed to combat this crisis, most of which are tracking or alert systems. In Apple devices, users have access to Find My, an application that can track devices added to the application. Its Android parallel is Find My Device, which works in a similar way. There are several existing GPS trackers that can be attached to clothes or placed in a pocket, however, these solutions have limited battery life. We also learned of a set of materials with the piezoelectric effect, meaning they are capable of converting mechanical energy to electrical energy through the displacement of particles on the molecular level. In simpler words, the material slightly deforms every time pressure is applied, and in reforming, the molecules generate electrical energy, able to harnessed by power banks. While many solutions have GPS tracking, most have excessive annuities and prices above fifty dollars. Many of these solutions also face difficulties with attachment, requiring processes and maintenance once applied.

Existing Solutions

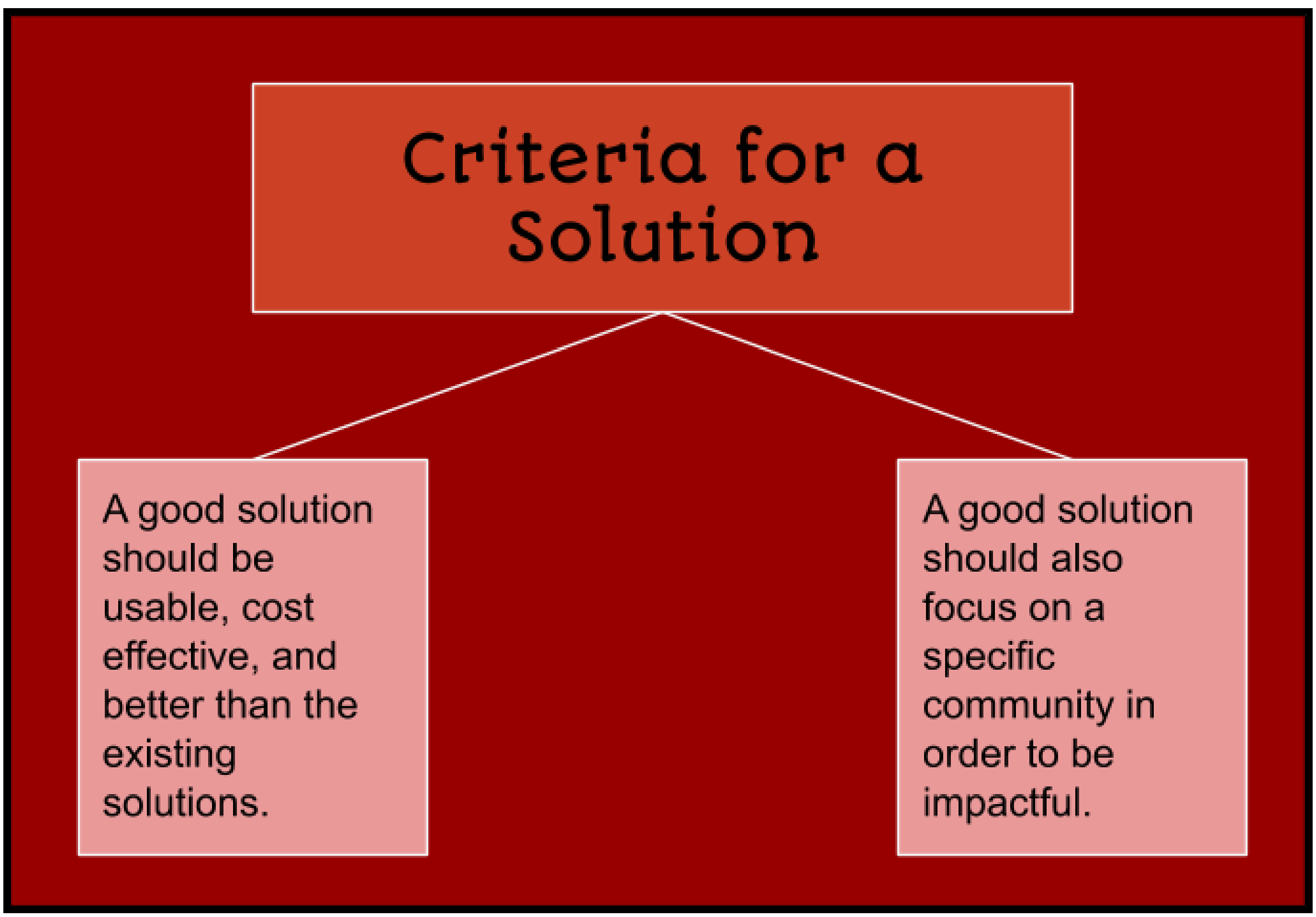
Category/ Products	**Tractive**	**Telemetry Nano pack**	**Skyleader 2 Pigeon Tracker**	**Find My**	**Find My Device**
GPS?	Yes	Yes	Yes	Yes	Yes
Monthly Subscription?	Yes	No	No	No	No
Self-Charging?	No	No	No	No	No
Waterproof?	Yes	Not mentioned	Not mentioned	N/A	N/A
Battery Life	Not mentioned	8 days	Not Mentioned	Varying Apple device battery life	Varying Android device battery life
Cost	$69.99 +$5.39	DIY/Not Mentioned	$50.95	No Extra Charge	No Extra Charge
Customizable	Not able to be customized	Customizable to specimen	Not able to be customized	Devices addable	Devices addable
Size	Weight of 35g	Weight of 5g	Not mentioned	N/A; application	N/A; application
Reliability	Durable and waterproof	Durability not mentioned	Durability not mentioned	Provides rough est of location	Provides rough est of location
Ease of Use	Easily attachable	Must be attached to an animal	Must be attached to an animal	Accessible to all Apple users	Accessible to all Android users

Design Development

What MUST be a part of your solution? This is called the criteria. What does your solution need to have in order to solve the problem? (NOTE: Don't discuss a specific solution here, just the characteristics of a good solution):

Criteria Statement

- It should solve a problem effectively and efficiently. This must be accomplished because even if the solution solves a problem, it should not create any extra problems which reduce the effectiveness of the solution. It should also use as little parts as possible because if it is too big, it might be hard to use. If it is too expensive, nobody will bother to buy it.
- The solution should focus on solving a problem in a specific community. This is necessary because a solution must impact a demographic or community in order to be powerful and to make a difference.
- One of the main features of our device is location-based tracking to find a missing person. Without this component, our design would be inefficient and pointless.
- Most existing solutions have a limited battery life, meaning that if the person is lost for a certain amount of time, the GPS signal will stop transmitting, which means that you wouldn't be able to track them.
- A lot of solutions have a monthly subscription and we have to make ours a one time purchase or talk to the police about them distributing it.

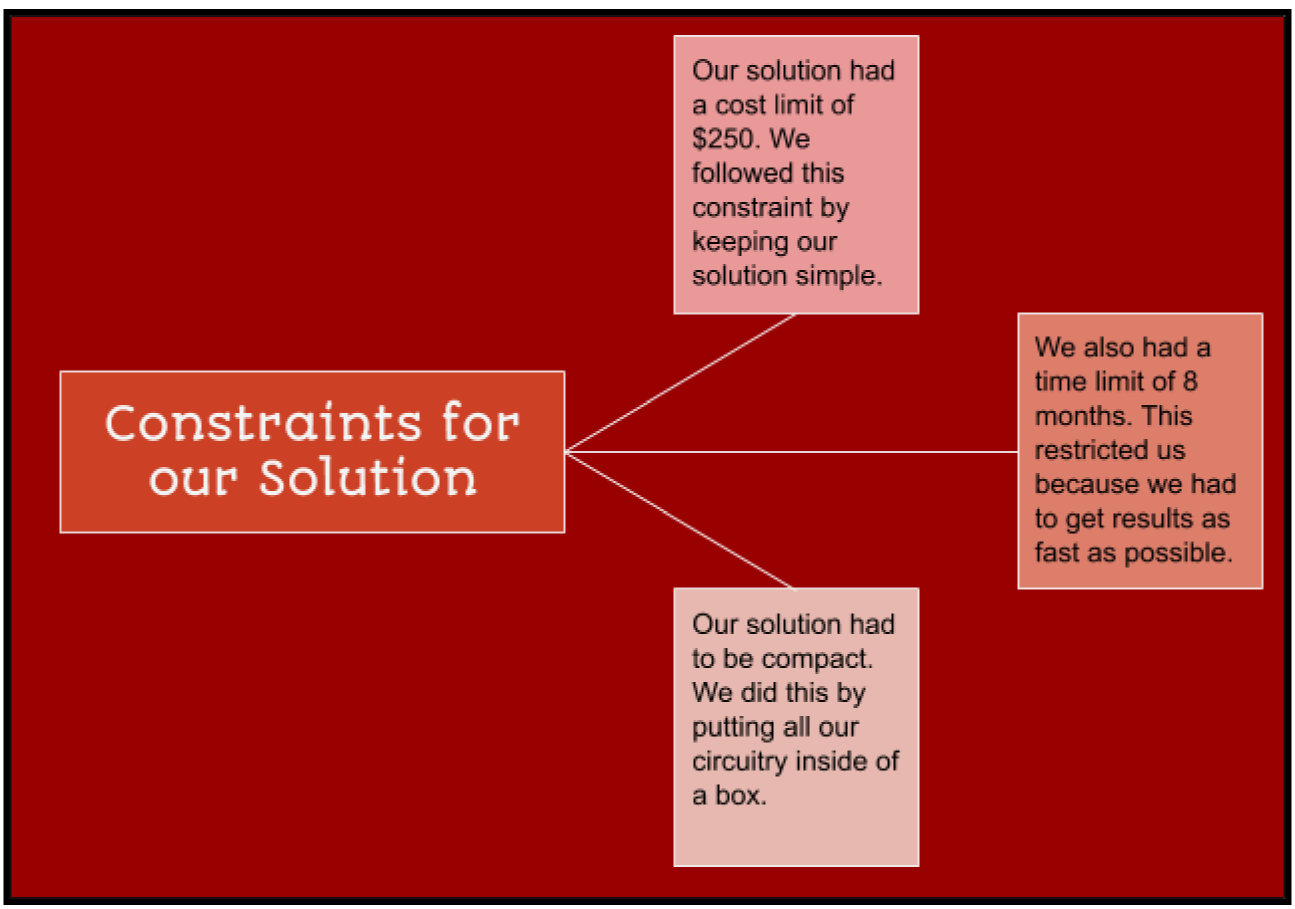


Constraints

What limits are there on your solution? These are called constraints. Does it need to be a certain size? A certain weight? Is the cost a factor? Write down all of the limits on your solution:

There were a few constraints on our solution that restricted us:

- We had to keep our solution under $250. This restricted us because we had to make our solution as simple as possible while sufficiently solving the problem. We managed to do this by trying to find the cheapest effective piezoelectric pad and GPS tracker. We also tried to only use necessary parts such as diodes or transistors
- We also only had 8 months to fully complete our project, which heavily limited us because we weren't able to fully test all the possible options on how we could harvest energy. We also had to get as much work done per meeting, and we did this by splitting up work and working at home
- Our solution also had to be usable and comfortable. We needed to make a comfortable part of the shoe, and we couldn't change the shoe too much or else it would be uncomfortable. Another major constraint was that the solution had to be discreet, as to not make it obvious that it is there.
- One of the main constraints that we had was that we needed to generate a sufficient amount of electricity so that our device could charge itself while walking. We needed to do this or else our solution would not work at all times, which would cause it to be ineffective.
- Our solution has to be waterproof because it would need to withstand a pond or some mud. If we don't do this, then the solution will be destroyed easily.



Our Solution

Our solution's main purpose was to create a self-charging GPS tracking device that could be discreetly used by all people, helping them out if they go missing. We split our solution into two parts; the self -charging aspect, and the GPS tracking aspect. We decided to use the aforementioned piezoelectric materials to generate this electricity in an eco-friendly and consistently available manner. We connected the piezoelectric pads to a model shoe sole, and tested the generation mechanism and recorded the data obtained.

We have developed a prototype that has the following 6 components.

1) Adafruit Flora Arduino based microcontroller (mini-computer)
2) Lithium-ion battery pack
3) GPS location tracker
4) Bluetooth device for wireless communication
5) Power generation module based on piezo pressure pads
6) Smartphone for collecting location data and plotting on google maps

High-Level Test plan for our Solution

#	Module	Test Criteria
1	Power Generator Module	Prove that the piezo pad circuitry can generate enough electricity to fully charge the 3.3v battery pack of the Third Eye solution
2	GPS Module	Prove that the Flora device with GPS module can connect to the GPS satellites reliably and can produce location (latitude, longitude) coordinates
3	Bluetooth Module	Prove that the Flora device with Bluetooth module can connect to a smartphone to wirelessly send location coordinates for plotting location real-time on Google maps application
4	Microcontroller Compute	Prove that the Adafruit Flora Arduino microcontroller can work with the 3.3v battery pack
5	Integrated Third Eye Solution	Prove that Flora + GPS + Bluetooth solution can monitor location real-time to track loved ones

Based on your criteria and constraints, what is your proposed solution to the problem you chose? Explain what it will look like and how it will work. If you can, include a detailed, labeled drawing:

Prototype

As our primary objective was to be able to sufficiently power a GPS tracker with a renewable energy source, we researched piezoelectricity. Piezoelectricity is the electric polarization of certain materials as a result of mechanical stress. This means that pressure on the material will We learned that there were many different types of materials that were piezoelectric, including quartz and Rochelle's salt. We eventually chose to use ceramics to harvest energy, because of its cheap price and effective electricity generation. The AC current can then be switched into DC current, which can then charge the GPS.

We used an AC to DC circuit so that the current would actually be useful. AC, or alternating current, periodically switches direction and is useful for power supplies. Direct current only goes in one direction and is useful for lights and devices. We also connected all the positive ends of the piezo pads and all the negatives to get one negative and one positive current.

We used the DC current generated to power a GPS tracker, which was placed inside the sole of the shoe, and the sole is in a very discreet area as to not make it very obvious.

Our current solution prototype also features the Adafruit Flora, a wearable and convenient microcontroller that will take a 3.3-volt current. The Flora is connected to a small GPS unit that actively charts its coordinates. The controller will send the coordinates to a Bluetooth transmitter that can sync to the user’s smartphone. Our end goal is to miniaturize the circuitry and parts to make the design as sleek and effective as possible.

1- Adafruit Flora Arduino Microcontroller

FLORA is Adafruit's fully-featured wearable electronics platform. It's round, sewable, Arduino compatible microcontroller designed to empower amazing wearables projects

2- Adafruit Battery Pack

3.7V Lithium-Ion Battery Rechargeable (Secondary) 2.5Ah
Dimensions: 1.97" L x 2.56" W x 0.31" H (50.0mm x 65.0mm x 8.0mm)

3- GPS Tracker

This module is the best way to add a GPS to your wearable project. It's part of the Adafruit Flora series of wearable electronics, designed specifically for use with the Flora motherboard. Installed on the PCB is the latest of our Ultimate GPS modules, a small, super-thin, low power GPS module with built-in data-logging capability! This module's easy to use, but extremely powerful:

- -165 dBm sensitivity, 10 Hz updates, 66 channels
- Designed for wearable use with the Flora system
- Only 20mA current draw
- RTC battery-compatible - sew a battery on to create an atomic-precision real-time clock
- Built-in data logging

- Internal patch antenna + u.FL connector for external active antenna
- Fix status LED

4- Bluetooth Device

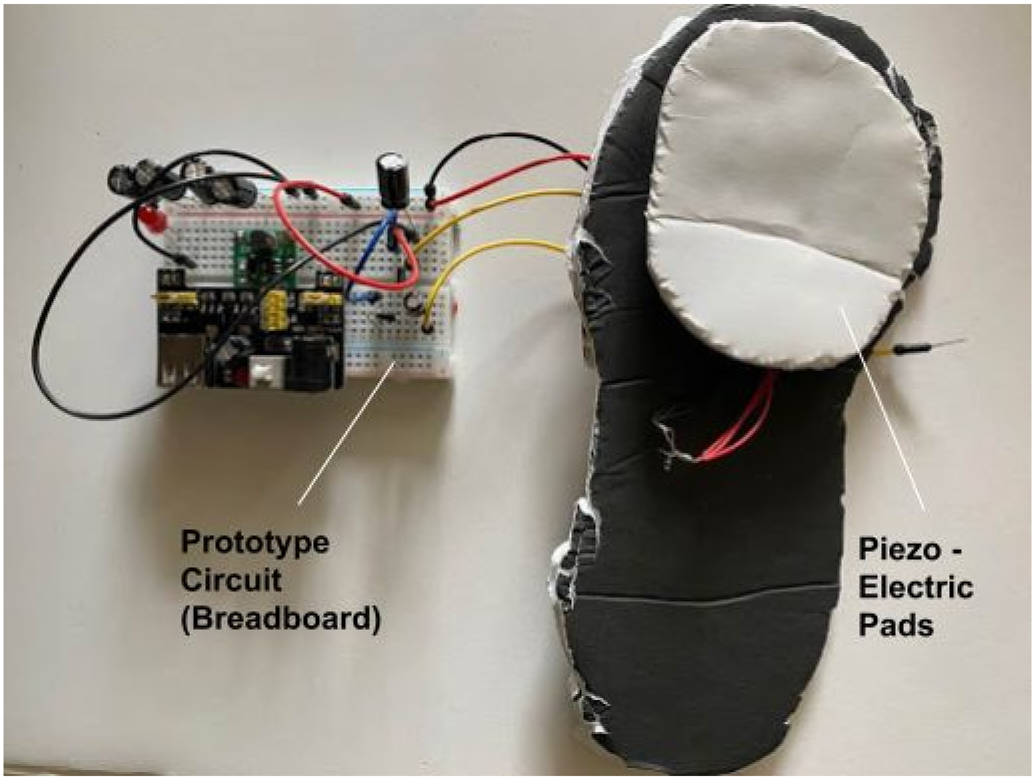
The Flora Bluefruit LE makes it easy to add Bluetooth Low Energy connectivity to Flora. It has 4 traces (or solder 4 wires) which forms the Bluetooth Low Energy!

Using our Bluefruit iOS App or Android App, we can quickly get our interactive project prototyped by using our iOS or Android phone/tablet as a controller.

In this profile, the Bluefruit acts as a data pipe, that can 'transparently' transmit back and forth from your iOS or Android device. We can also use our iOS App or Android App, or write your own to communicate with the UART service.

5- Power Generation Module Prototype

We learned that harvesting energy from human body movements is possible using piezo pressure pads. By applying pressure on piezo pads, we can convert mechanical energy to electrical energy and store the energy generated in capacitors prior to transferring into rechargeable battery packs.



6- Smartphone

The sixth component in our solution is the smartphone which connects to the Flora Bluetooth device wirelessly to transmit the GPS location coordinates for plotting location real-time on smartphones. We plan to support both Android and iOS versions.

Bill of Materials

Flora GPS Starter Pack	$89.95
Adafruit Perma-Proto Half Sized Breadboard	$4.50
Sewable CR2032 Battery Holder	$1.95
Lithium Polymer Battery	$9.95
Lithium Coin Cell Battery	$0.95
USB Cable	$2.95
Flora Wearable Bluefruit LE Module	$17.50
Piezo Pads (set of 3)	$19.47
Donated Android Phone	$10.00
SMRAZA Basic Starter Kit	$14.39
Icy Station Mini DC to DC Converter	$9.99
Crenova MS8233D Digital Multimeter	$21.99
TOTAL COST	**$197.10**

Even though the total price was a high result, a majority of the components bought were used for testing purposes, including the multimeter and the extra breadboard. We didn't use them because our solution changed over time, but they helped us improve our design.

Materials

1. FLORA GPS Starter Pack
   - We used this as the GPS to transmit the location to the phone. This had all the necessary tools to transmit information via GPS signals.

2. Sewable CR2032
   - This was a very simple battery holder, designed to contain batteries to power our solution.

3. Lithium-Ion Polymer Battery - 3.7v 1200mAh
   - This was used as our long term battery, due to its large amount of power. We put this in our battery holder, allowing us to power our solution for long term situations.

4. Lithium Coin Cell Battery
   - We used this as a smaller battery, for a short term because of its weaker amount of power.

5. USB Cable - USB A - Micro B
   - We used this cable to connect our different circuits. We connected the piezo pads to the GPS tracker

6. Flora Wearable Bluefruit LE Module
   - This is a wearable electronics that can easily be hooked up to the GPS. We also used this because it is easy to use in a small and compact design. It also included 66 channels.

7. Icstation Mini DC to DC Voltage Converter
   - We used this to convert AC to DC voltage, because the input power was AC, and the GPS needed DC power.

8. Smraza Basic Starter Kit
   - This kit included most of the wiring components that we needed for the basic circuitry. It included a breadboard, power supply, jumper wires, resistors, LED and transistors.

9. 15 pack of 20mm Piezo Discs.
   - We used these piezoelectric pads to power our solution through pressure. Piezoelectricity is a renewable source of energy that is generated through different ceramics.

10. 20 pack of 22mm Piezo Discs.
    - This is just a larger version of the previous piezo elements.

Software used

1. Android Studio
   - This is an app developing software which we used to connect the phone to the GPS tracker via Bluetooth
2. Arduino IDE
   - We used the Arduino IDE to establish connections and share data.

Building Procedure

1. Connect all of the negative wires together and all of the positive wires together of piezo pads (as many as needed) and then solder together.

2. Glue small squares of styrofoam on top of each for more electricity generation.

3. Connect the positive wires from the piezo pads to the negative end of a capacitor.

4. Connect the negative wires from the piezo pads to the positive end of a diode.

5. Connect the positive end of the previous capacitor to the negative end of the previous diode.

6. Connect the negative end of Diode 1 to the positive end of Diode 2.

7. Connect the negative end of Diode 2 to the positive end of Capacitor 2

8. Connect the positive end of Diode 1 to the negative end of Capacitor 2

9. Connect the output to a battery.

10. Connect the battery to the GPS.

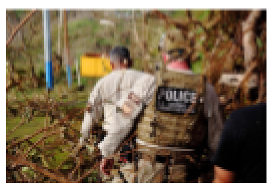
11. Create an app in Android studio to connect location to the phone through Bluetooth

Testing Solution

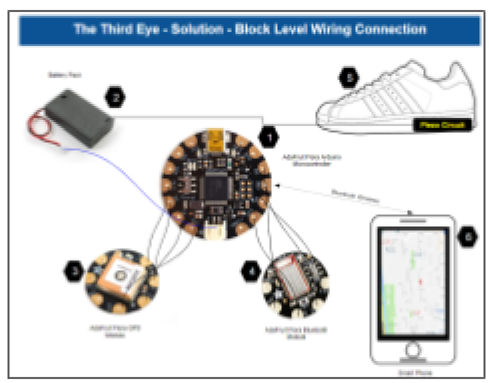
How will you test your solution? The BEST way to test your solution is to build a working model or a prototype that you can actually use. Or you can guess how your solution will work BASED ON your research. Which method will you use and why?:

We tested our prototype in multiple ways. We first used our thumb to measure the voltage generated from piezo pads with and without styrofoam. This was used to power an LED to demonstrate that the voltage generated is enough power. The second test that we did was to track our movement outside using the GPS, to see if the tracker worked. For our final solution, we are planning to combine these to make a self-charging GPS tracker. We decided to make a working prototype because we can get a much clearer understanding of our solution, and so that we get actual data.

Built our prototype → Collected 20 Samples from various personas to prove Piezo pads can generate sustained voltage of 3.3v to power Adafruit Flora device → Developed mathematical model to prove power generation model, GPS, Bluetooth model functionality for real-time monitoring



We partnered with local communities and sheriff office to understand the Search and Rescue process



MEGGiTT
Meggitt Training Systems

We learned from 6 experts in our communities to on location monitoring devices and the process of converting mechanical energy to electrical energy

Test case scenarios

We plan to test our prototype for the following test scenarios to completely validate our Third Eye solution prototype.

#	Module	Test Criteria
1	Power Generator Module	Prove that the piezo pad circuitry can generate enough electricity to fully charge the 3.3v battery pack of the Third Eye solution
2	GPS Module	Prove that the Flora device with GPS module can connect to the GPS satellites reliably and can produce location (latitude, longitude) coordinates
3	Bluetooth Module	Prove that the Flora device with Bluetooth module can connect to a smartphone to wirelessly send location coordinates for plotting location real-time on Google maps application
4	Microcontroller Compute	Prove that the Adafruit Flora Arduino microcontroller can work with the 3.3v battery pack
5	Integrated Third Eye Solution	Prove that Flora + GPS + Bluetooth solution can monitor location real-time to track loved ones

Location collection Program (GPS_Hardware_Serial_LOCUS_Status)

```
// This code turns on the LOCUS built-in datalogger. The datalogger
// turns off when power is lost, so you MUST turn it on every time
// you want to use it!

#include <Adafruit_GPS.h>

// what's the name of the hardware serial port?
#define GPSSerial Serial1

// Connect to the GPS on the hardware port
Adafruit_GPS GPS(&GPSSerial);

// Set GPSECHO to 'false' to turn off echoing the GPS data to the Serial console
// Set to 'true' if you want to debug and listen to the raw GPS sentences
#define GPSECHO  true

void setup()
{
  //while (!Serial);  // uncomment to have the sketch wait until Serial is ready

  // connect at 115200 so we can read the GPS fast enough and echo without dropping chars
  // also spit it out
  Serial.begin(115200);
  delay(1000);
```

```
  Serial.println("Adafruit GPS logging start test!");

  // 9600 NMEA is the default baud rate for MTK - some use 4800
  GPS.begin(9600);

  // You can adjust which sentences to have the module emit, below
  // Default is RMC + GGA
  GPS.sendCommand(PMTK_SET_NMEA_OUTPUT_RMCGGA);
  // Default is 1 Hz update rate
  GPS.sendCommand(PMTK_SET_NMEA_UPDATE_1HZ);
  // Request updates on antenna status, comment out to keep quiet
  GPS.sendCommand(PGCMD_ANTENNA);
  // Ask for firmware version
  GPS.sendCommand(PMTK_Q_RELEASE);

  Serial.print("\nSTARTING LOGGING....");
  if (GPS.LOCUS_StartLogger())
    Serial.println(" STARTED!");
  else
    Serial.println(" no response :(");
}

uint32_t updateTime = 1000;

void loop()                     // run over and over again
{
  char c = GPS.read();
  // if you want to debug, this is a good time to do it!
  if ((c) && (GPSECHO))
    Serial.write(c);

  if (millis() > updateTime)
  {
    updateTime = millis() + 1000;
    if (GPS.LOCUS_ReadStatus()) {
       Serial.print("\n\nLog #");
       Serial.print(GPS.LOCUS_serial, DEC);
      if (GPS.LOCUS_type == LOCUS_OVERLAP)
        Serial.print(", Overlap, ");
      else if (GPS.LOCUS_type == LOCUS_FULLSTOP)
        Serial.print(", Full Stop, Logging");

      if (GPS.LOCUS_mode & 0x1) Serial.print(" AlwaysLocate");
      if (GPS.LOCUS_mode & 0x2) Serial.print(" FixOnly");
      if (GPS.LOCUS_mode & 0x4) Serial.print(" Normal");
      if (GPS.LOCUS_mode & 0x8) Serial.print(" Interval");
      if (GPS.LOCUS_mode & 0x10) Serial.print(" Distance");
      if (GPS.LOCUS_mode & 0x20) Serial.print(" Speed");

      Serial.print(", Content "); Serial.print((int)GPS.LOCUS_config);
      Serial.print(", Interval "); Serial.print((int)GPS.LOCUS_interval);
      Serial.print(" sec, Distance "); Serial.print((int)GPS.LOCUS_distance);
      Serial.print(" m, Speed "); Serial.print((int)GPS.LOCUS_speed);
      Serial.print(" m/s, Status ");
```

```
      if (GPS.LOCUS_status)
        Serial.print("LOGGING, ");
      else
        Serial.print("OFF, ");
      Serial.print((int)GPS.LOCUS_records); Serial.print(" Records, ");
      Serial.print((int)GPS.LOCUS_percent); Serial.print("% Used ");

    }//if (GPS.LOCUS_ReadStatus())
  }//if (millis() > updateTime)
}//loop
```

Data Dump for Google Map Plotting

```
// Test code for Adafruit GPS modules using MTK3329/MTK3339 driver
//
// This code turns on the LOCUS built-in datalogger. The datalogger
// turns off when power is lost, so you MUST turn it on every time
// you want to use it!
//

#include <Adafruit_GPS.h>

// what's the name of the hardware serial port?
#define GPSSerial Serial1

// Connect to the GPS on the hardware port
Adafruit_GPS GPS(&GPSSerial);

// Set GPSECHO to 'false' to turn off echoing the GPS data to the Serial console
// Set to 'true' if you want to debug and listen to the raw GPS sentences
#define GPSECHO  true

void setup()
{
  //while (!Serial);  // uncomment to have the sketch wait until Serial is ready

  // connect at 115200 so we can read the GPS fast enough and echo without dropping chars
  // also spit it out
  Serial.begin(115200);
  delay(1000);
  Serial.println("Adafruit GPS logging data dump!");

  // 9600 NMEA is the default baud rate for MTK - some use 4800
  GPS.begin(9600);

  GPS.sendCommand(PMTK_SET_NMEA_OUTPUT_OFF);

  while (GPSSerial.available())
     GPSSerial.read();

  delay(1000);
  GPS.sendCommand("$PMTK622,1*29");
  Serial.println("----------------------------------------------------");
}
```

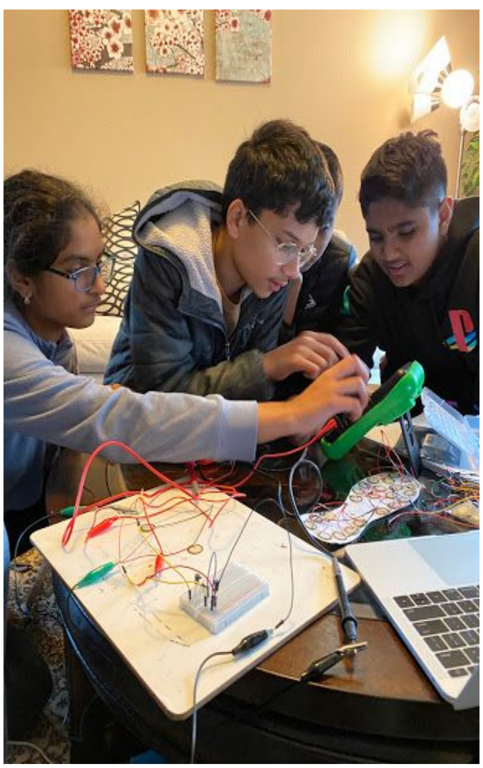
```
uint32_t updateTime = 1000;

void loop()                      // run over and over again
{
  if (Serial.available()) {
    char c = Serial.read();
    GPSSerial.write(c);
  }
  if (GPSSerial.available()) {
    char c = GPSSerial.read();
    Serial.write(c);
  }
}//loop
```

Testing Criteria

Explain how you tested your prototype or model. Be sure to include every step of your testing including all safety precautions that were taken. If not stated it will be assumed no safety precautions were taken. If you are using research to guess how your solution will work, explain step-by-step how it will work and why:

We tested every single component in our prototype for specific criteria. In the section below we will comprehend our test procedures and observations for each step.

#	Module	Test Criteria
1	Power Generator Module	Prove that the piezo pad circuitry can generate enough electricity to fully charge the 3.3v battery pack of the Third Eye solution
2	GPS Module	Prove that the Flora device with GPS module can connect to the GPS satellites reliably and can produce location (latitude, longitude) coordinates
3	Bluetooth Module	Prove that the Flora device with Bluetooth module can connect to a smartphone to wirelessly send location coordinates for plotting location real-time on Google maps application
4	Microcontroller Compute	Prove that the Adafruit Flora Arduino microcontroller can work with the 3.3v battery pack
5	Integrated Third Eye Solution	Prove that Flora + GPS + Bluetooth solution can monitor location real-time to track loved ones



Data Collection & Analysis - Power Generation Module:

Testing Procedure For Cardboard FootPrint:

1. Gather the multimeter, circuit, and the cardboard footprint
2. Place the multimeter, circuit, and the cardboard footprint on a flat surface
3. Connect the multimeter to the circuit
4. Connect the circuit to the cardboard footprint
5. Switch on the multimeter
6. Person 1 starts pressing on the cardboard footprint with the right foot for 2 sec
7. Record the highest amount of DC voltage shown on the multimeter
8. Do steps 6-7 5 times,
9. switch to the left foot and repeat steps 6-8
10. Do steps 6-9 with Person 2, 3, 4, 5, 6, 7
11. Calculate the average of each person
12. Turn off the multimeter and put the circuit, disconnect the wires, and put the cardboard footprint in a safe place.

Testing Procedure For Styrofoam:

1. Gather the whiteboard with the piezoelectric pads and the multimeter
2. Place the whiteboard with the piezoelectric pads and the multimeter on a flat surface
3. Connect all the wires from the whiteboard to the multimeter
4. Switch on the multimeter
5. Push with your dominant thumb for 2 sec on one of the piezo pads with no styrofoam
6. Record the highest DC voltage shown on the multimeter
7. Repeat steps 5-6 five times
8. Place each of your thumbs on each of the piezo pads without styrofoam.
9. Push for 2 sec
10. Repeat steps 6-7
11. Place your dominant thumb on one of the piezo pads with styrofoam
12. Repeat steps 9-10
13. Place each of your thumbs on 2 piezo pads with styrofoam
14. Repeat step 12
15. Ask another volunteer to come and help for the next step
16. Place each of your thumbs and the volunteer's dominant thumb on 3 of the piezoelectric pads with styrofoam.
17. Repeat step 14
18. Now both the volunteer and you place both of your thumbs on 4 of the piezoelectric pads with styrofoam.
19. Repeat step 17; For the next step ask another volunteer to come and help
20. One of the volunteers and you now place your thumbs on 4 of the piezoelectric pads with styrofoam. The other volunteer places their dominant thumb on one of the remaining piezo pads with styrofoam.; Repeat step 19
21. Now you and the 2 other volunteers place 6 of your thumbs on all 6 of the piezo pads with styrofoam
22. Repeat step 22; Put all materials back in their respective places.

Formulas for calculating Energy generated:

$$V=(-g33*h*(f/a))= -(g33*h*(f/(d^2*(\pi/4)))$$

V: The expected peak strain due to the deformation of the material.
g33: It is the piezoelectric constant (Vm / N).
h: The length or thickness of the piezoelectric.
f: Force that is printed on the piezoelectric ceramic (N).
d:Effective diameter of the piezoelectric ceramic.
a: Area of the piezoelectric ceramic.

Data Prediction:

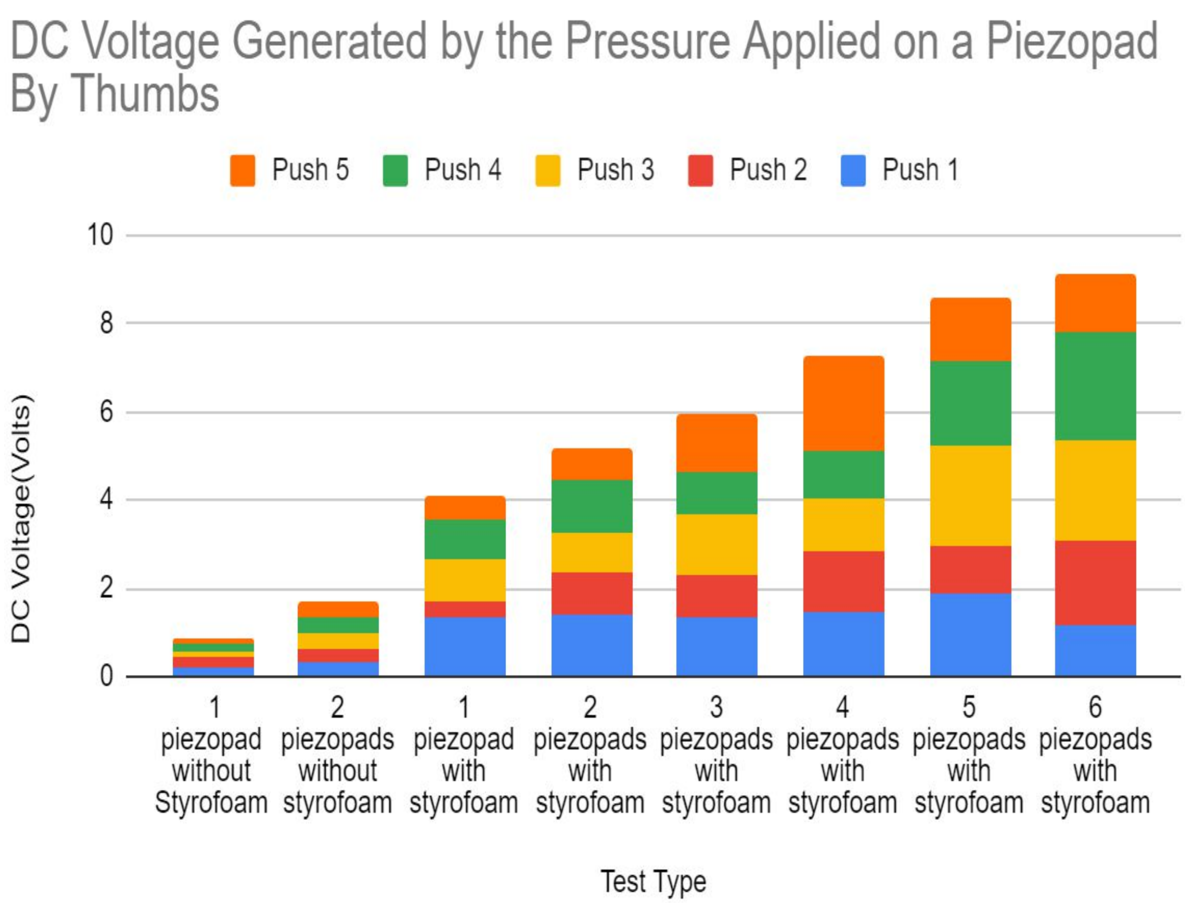
Our prediction is that the piezo pads with styrofoam would create more energy. This is because the piezo pad with the styrofoam creates more pressure when pushed down by a thumb. Also, we guessed the more piezo pads that we add, the more DC voltage that is produced. This is because the added piezo pads mean there is energy being produced by multiple piezo pads.

Data Analysis:

We collected numerous amounts of data testing by putting pressure on both piezo pads with styrofoam and without. We also tested with multiple piezo pads at the same time.

DC Voltage Generated by the Pressure Applied on a Piezopad By Thumbs

Test Type	Push 1	Push 2	Push 3	Push 4	Push 5
1 piezopad without Styrofoam	0.2	0.23	0.13	0.18	0.14
2 piezo pads without styrofoam	0.31	0.31	0.36	0.38	0.36
1 piezopad with styrofoam	1.35	0.37	0.91	0.92	0.56
2 piezo pads with styrofoam	1.43	0.93	0.89	1.19	0.76
3 piezo pads with styrofoam	1.37	0.95	1.35	0.97	1.28
4 piezo pads with styrofoam	1.48	1.35	1.22	1.07	2.14
5 piezo pads with styrofoam	1.87	1.1	2.29	1.89	1.41
6 piezo pads with styrofoam	1.15	1.94	2.26	2.47	1.28



DC Voltage Generated by the Pressure Applied on a Piezopad By Thumbs

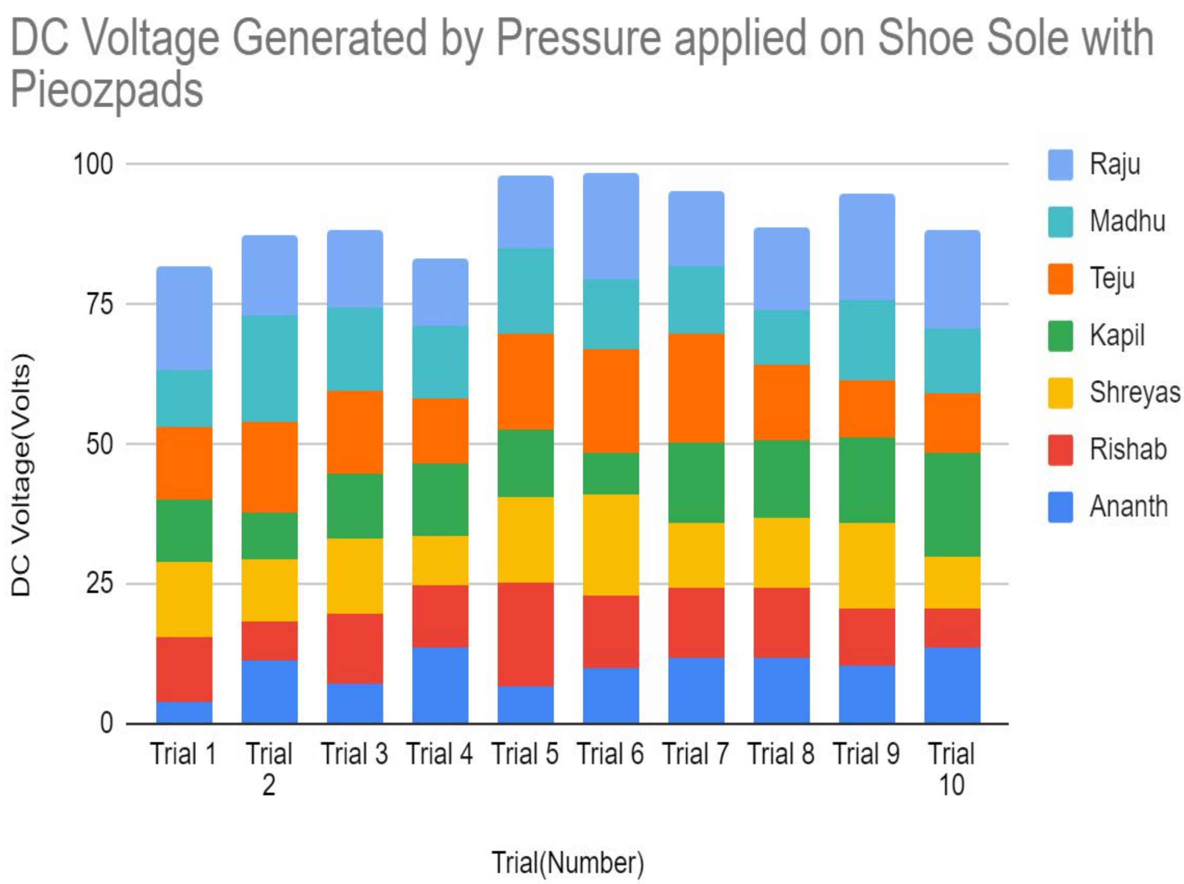
Test Type	Push 1	Push 2	Push 3	Push 4	Push 5
1 piezopad without Styrofoam	0.2	0.23	0.13	0.18	0.14
2 piezo pads without styrofoam	0.31	0.31	0.36	0.38	0.36

DC Voltage Generated by the Pressure Applied on a Piezopad By Thumbs

Test Type	Push 1	Push 2	Push 3	Push 4	Push 5
1 piezopad with styrofoam	1.35	0.37	0.91	0.92	0.56
2 piezo pads with styrofoam	1.43	0.93	0.89	1.19	0.76
3 piezo pads with styrofoam	1.37	0.95	1.35	0.97	1.28
4 piezo pads with styrofoam	1.48	1.35	1.22	1.07	2.14
5 piezo pads with styrofoam	1.87	1.1	2.29	1.89	1.41
6 piezo pads with styrofoam	1.15	1.94	2.26	2.47	1.28

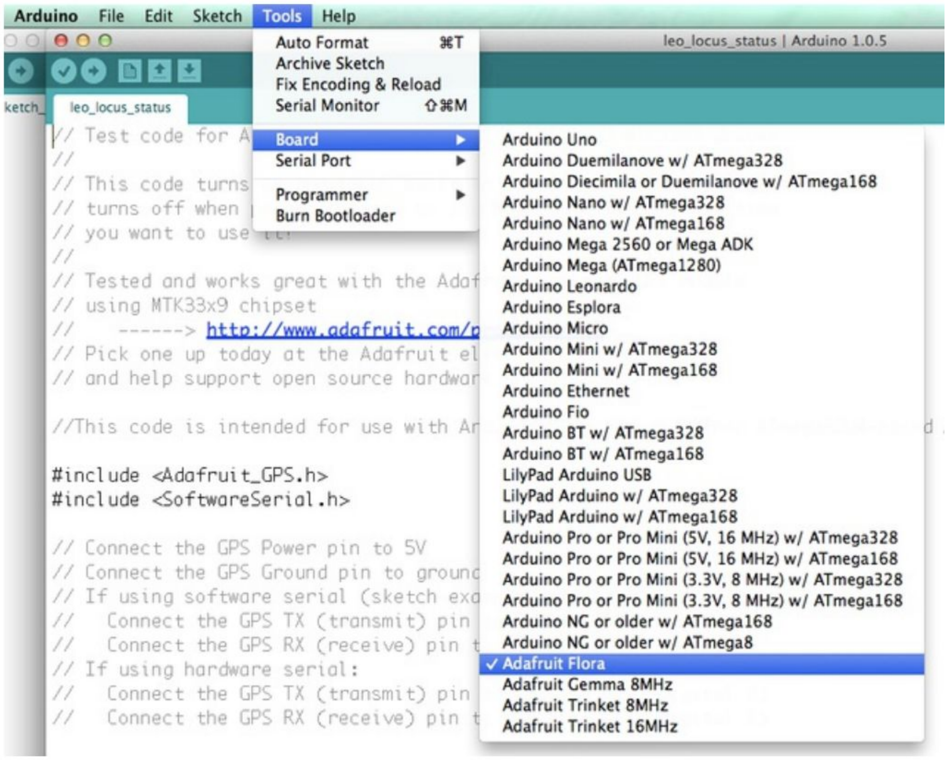
DC Voltage Generated by Pressure applied on Shoe Sole with Piezo Pads

Person	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Average
Ananth	3.74	11.34	6.94	13.63	6.85	9.93	11.64	11.72	10.59	13.77	10.015
Rishab	11.8	7	12.83	10.97	18.63	13.1	12.62	12.83	10.14	6.87	10.847
Shreyas	13.63	10.97	13.56	8.93	14.95	17.79	11.58	12.54	14.98	9.05	12.798
Kapil	10.84	8.7	11.65	13.08	12.03	7.68	14.38	13.78	15.67	18.72	12.653
Teju	12.87	15.86	14.76	11.38	17.35	18.35	19.76	13.34	9.87	10.82	14.436
Madhu	10.21	19.04	14.73	13.17	15.09	12.56	11.67	9.83	14.39	11.32	13.201
Raju	18.86	14.63	13.87	12.23	13.32	19.03	13.85	14.58	19.02	17.8	15.719



Data Collection & Analysis - GPS & Bluetooth Module and Integrated Solution:

Launching Arduino Programs

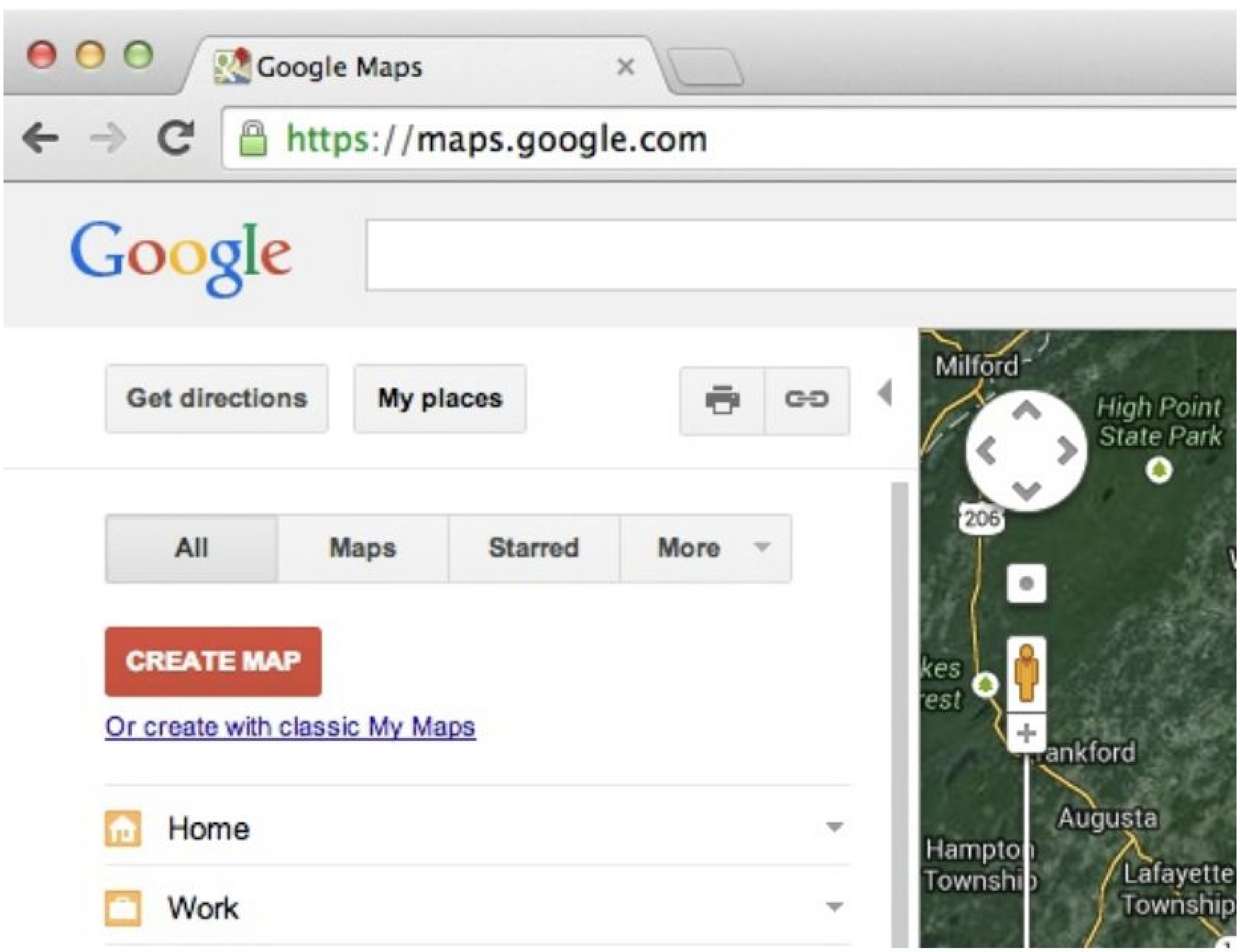


By clicking on the download icon at the top of the Arduino sketch the program will get downloaded to the Adafruit Flora board, and the LEDs start blinking indicating the ZGPS data and Bluetooth are functioning.

Location Coordinates Extraction

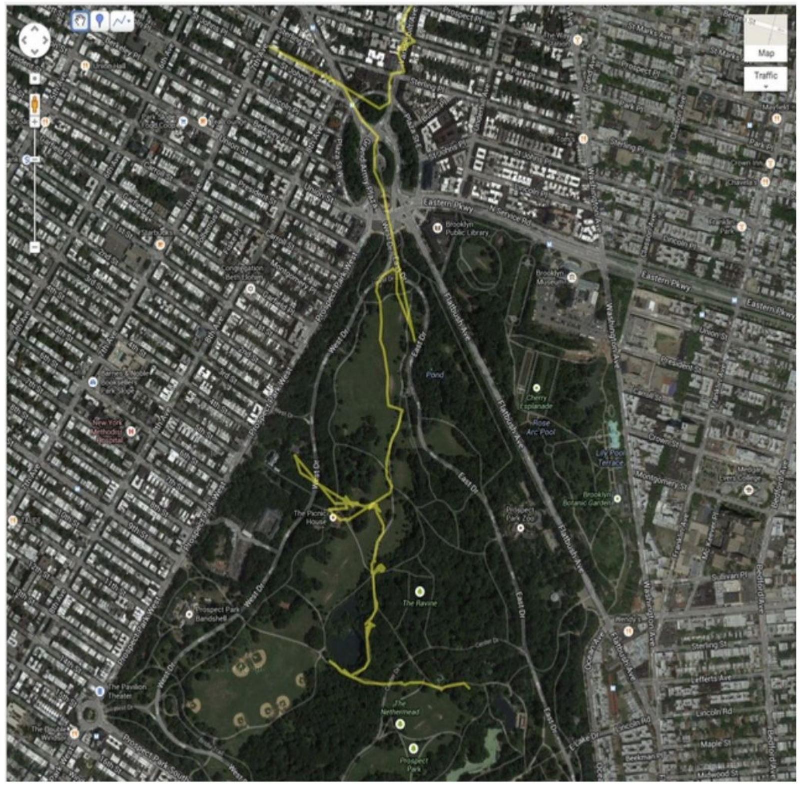
After the data is collected, copy the GPS location coordinates from the Serial Monitor and paste it on the LOCUS Parser website maintained by the Adafruit. This script automatically formats the GPS coordinates to something that can be understood by Google Maps.

Plotting coordinates on Google Maps Real-Time



It is critical to plot the coordinates real-time on Google map so it is possible to monitor the location of the loved ones. Google API allows us to overlay the coordinates on the map to allow real-time plotting and rendering of the map.

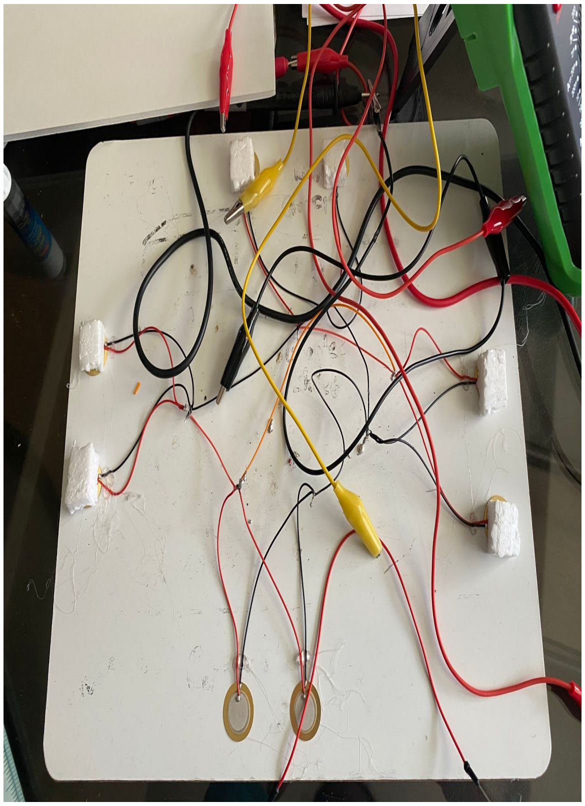
Below is an example of the Android phone screen to connect the smartphone to the Adafruit Flora device and the plotting of coordinates overlayed on the Google map showing the path of walking in our neighborhood.



Errors

What problems did you find with your solution? Be specific since you will need to redesign based on these problems:

Our team experienced quite a few errors in our prototype due to our budgeted use of complex parts. For example when we tested the amount of DC Voltage produced by one piezo pad was not enough to charge the GPS tracker(3.3 Volts). We also realized that the piezo pad needed more pressure to generate more volts. Finally, another error was the pressure from a thumb was not enough to charge the GPS tracker.



Describe all of the changes you made to your prototype or model (or proposed prototype) after your first test. Why will these changes improve your solution?:

Problem #1: For the GPS tracker to start charging it needed an input of at least 3.3 DC volts. Just one piezo pad without styrofoam could only get a max of 0.23 volts.

Solution: To solve this problem we added one more piezo pad. This did help increase the DC Voltage. The maximum was 0.38 volts.

Problem #2: Even though we increased the number of piezo pads there was still not enough DC Voltage to charge the GPS tracker. This is because there was not enough pressure being applied.

Solution: To fix this we hot glued a 2 cm x 2 cm x 0.5 cm styrofoam block on top of the ceramic of the piezo pad. This helped increase the pressure. For 1 piezo pad with styrofoam, the maximum DC voltage was 1.35 volts. When we increased the amount of piezo pads to 6 with styrofoam the maximum DC voltage was 2.47 volts.

Problem #3: The styrofoam's pressure did increase the amount of DC Voltage, but it was still not enough to charge the GPS tracker. At this point we realized the pressure from the thumb was not enough to charge the GPS tracker.

Solution: To solve this problem we decided to use the pressure of the foot. Particularly the pressure from the ball of the foot when a step is taken. We tested this and the minimum we got from the whole table was 3.74 volts and the max was 19.76 volts. This was more than enough to charge the GPS tracker.

Potential Sources of Error

What are your potential sources of error? Remember, this doesn’t mean "Did everything work?", all tests have potential sources of error, so make sure you understand what that means. Explain how these sources of error could have affected your results:

As we measure the amount of DC voltage generated by the pressure applied on the piezo pad, we are not sure if the pressure is enough. We are also not sure if the pressure applied by the foot while stepping is applying the pressure is in the right spot. Also, the distance traveled affects the number of volts generated. To avoid these errors we placed the piezo pads on the ball of the foot to have a less likely chance of these errors happening.

Our potential sources of error were mainly involved with the amount of pressure aspect of our testing. The pressure could differ according to the weight of the person, the distance they travel, and how light or hard their steps are. All of these aspects affected the amount of DC voltage that was generated.

Weight: If a person weighed less than they would produce fewer volts, whereas if you weighed more than you would produce more volts. This is because the more you weigh the more pressure that is being applied when you take a step. So the more you weigh the more likely you are able to generate at least 3.3 volts to start charging the GPS tracker.

Distance: I a person were only to walk ten steps with the Third Eye it would not be enough pressure to store the energy to charge the GPS tracker for an extended period of time. This is because as soon as you stop walking, the number of volts generated starts to gradually decrease. So the best time to wear this is when you are going on long walks and when you are going to the gym.

The style of walking: The way a person walks also affects the amount of pressure applied on a piezo pad. The lighter their steps are the pressure they apply also decreases. This also affects the DC voltage generated.

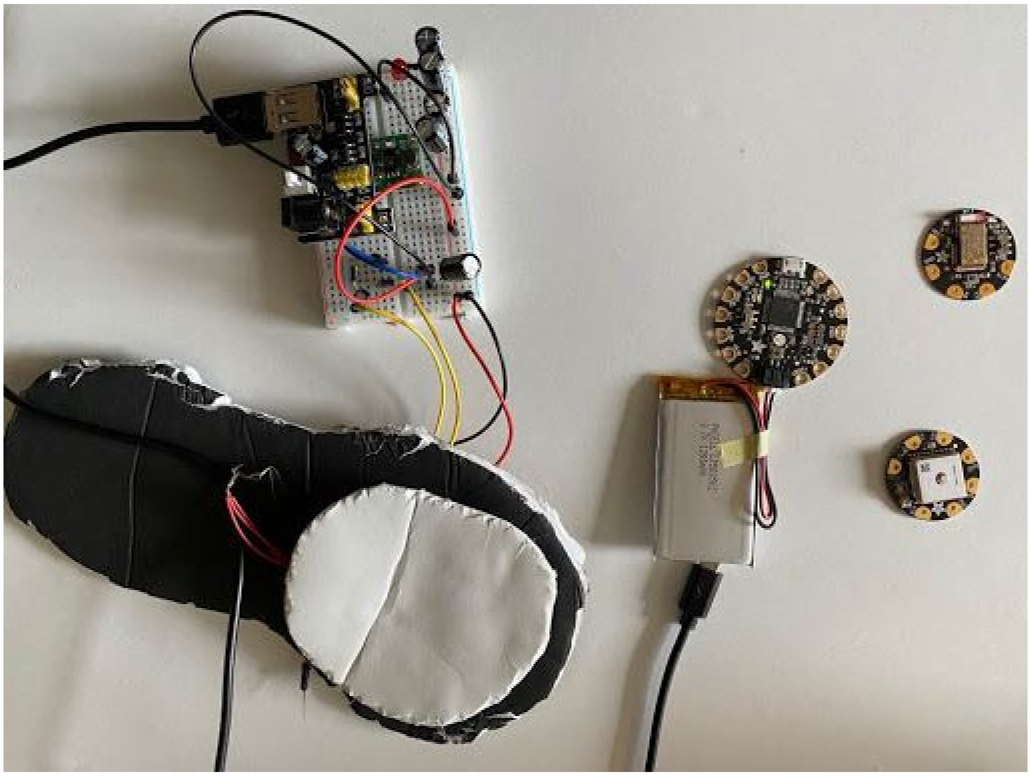
Another problem was with the GPS tracker. The GPS tracker was not 100% reliable. Some potential errors included offline storage running out, the battery running out, the Bluetooth being disconnected, and the GPS not working inside.

Offline Storage: For the GPS to be working in areas where Wi-fi is not available, it should be able to do offline tracking. But the potential error is that the offline storage could run out before the missing person is found.

Battery: Even though the Third Eye is a rechargeable device, it needs constant movement for the battery in the GPS tracker to be working. If the battery runs out before the person is found, the closest we could get to tracking them is the last coordinate that was sent to the phone before the battery ran out.

Bluetooth: The Third Eye sends the location of the missing person to your phone. For this to work without a USB connection, it needs Bluetooth. But if the Bluetooth is disconnected from the phone there is no way to know the location of the missing person.

Indoor tracking: Another problem we found is that the GPS tracker does not work inside. This might be because of the satellite connection not working inside. This would be a problem if the missing person is being kept in a big building. But we would still be able to track them going to the building.



Connectivity: Similar to the pigeon tracking efforts, we will be exploring installing receivers in zones that have higher search and rescue operations that are programmed to receive signals from specific transmitters and work with the local search and rescue teams to subsidize the cost of the equipment. This approach will eliminate the cost to install SIM cards in the devices. In addition, when 5G connectivity standards are established we will be able to adopt them as well.

Conclusion

What conclusions can you draw based on the data you gathered during your tests?:

Based on the data gathered from our prototype, our insole design has the capability to generate the 3.3 volts necessary for the GPS tracker and connected microcontroller, thus proving that a GPS-based self-charging shoe is possible and effective. We heavily relied on piezoelectric energy generating, as it is generated through pressure and it is renewable. Through our multiple tests, we also demonstrated that both GPS and Bluetooth connections can work reliably thus resulting in the Third Eye, a cost-effective (less than $150), reliable and self-charging location-monitoring device to track our loved ones.

#	Module	Test Criteria	Result
1	Power Generator Module	Prove that the piezo pad circuitry can generate enough electricity to fully charge the 3.3v battery pack of the Third Eye solution, including the GPS module	**PROVED**

2	GPS Module	Prove that the Flora device with GPS module can connect to the GPS satellites reliably and can produce location (latitude, longitude) coordinates through a series of tests	**PROVED**
3	Bluetooth Module	Prove that the Flora device with Bluetooth module can connect to a smartphone to wirelessly send location coordinates for plotting location real-time on Google maps application using an Android Studio app effectively	**PROVED**
4	Microcontroller Compute	Prove that the Adafruit Flora Arduino microcontroller can work with the 3.3v battery pack to power the GPS module	**PROVED**
5	Integrated Third Eye Solution	Prove that Flora + GPS + Bluetooth solution can monitor location real-time and accurately to track loved ones without the worry of losing battery	**PROVED**

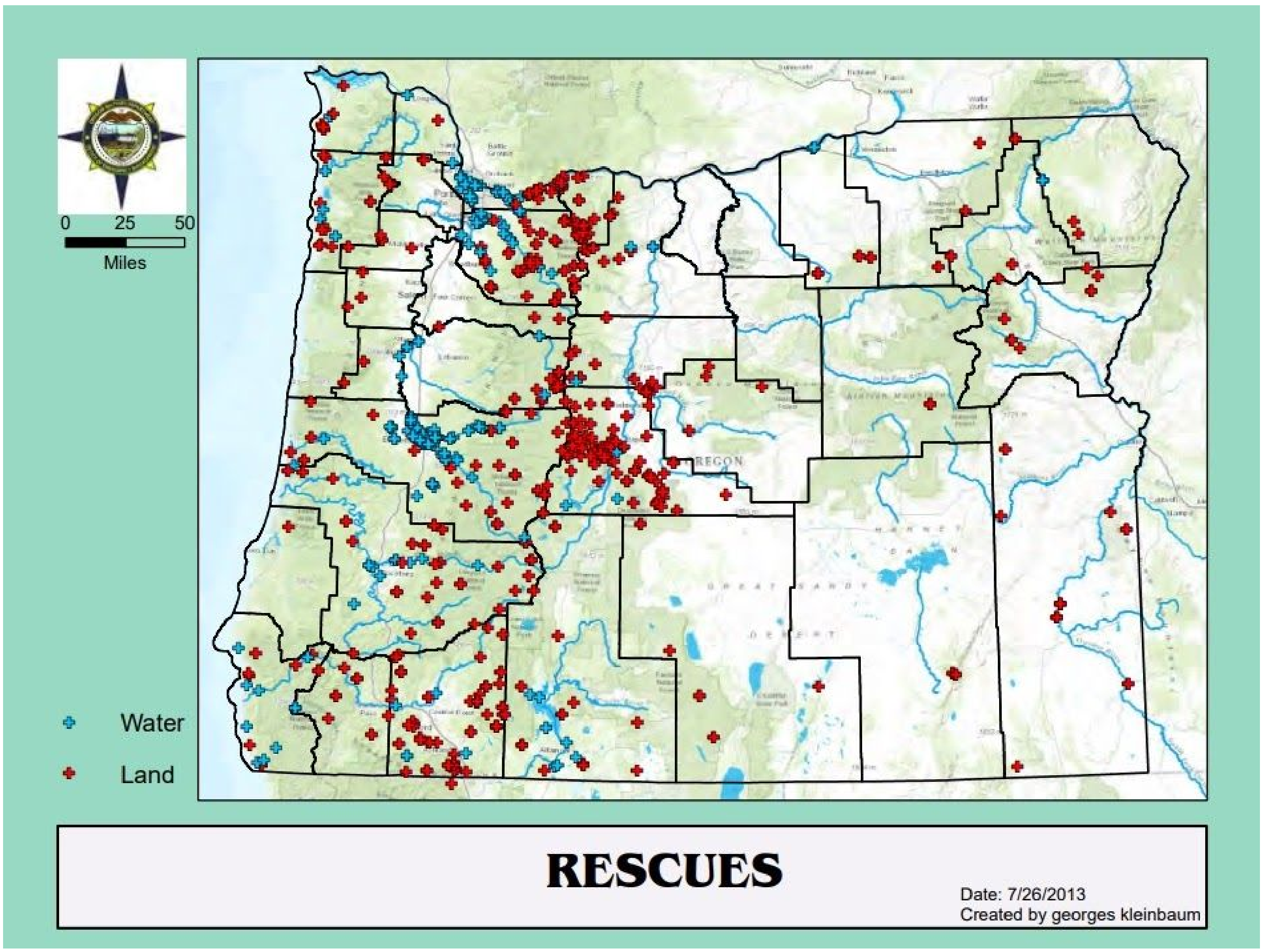
We demonstrated successfully that our integrated solution follows this criterion effectively and efficiently through a series of different tests proving one aspect of the design. We tested our power generator through a series of presses on our piezoelectric pad with our thumb. The GPS module was tested by walking outside and then looking at the real-time data. We managed to connect the GPS through Bluetooth using an Android Studio app. We used a few cables to connect the Bluetooth module to the Flora device to finish up our solution. Overall, these aspects came together in our successful Third Eye solution, to track loved ones effectively and with ease.

To address long-range solution we plan to develop a solution similar to how the bird migration is monitored that is a small device that is attached to the bird is capable of sending specific signatures and in high-risk neighborhoods we could install multiple tracking stations that can record the signatures each time they receive the sent device signatures to be able to monitor and communicate location real-time. The black dot in the neighborhood picture represents the receiving stations. As children walk from their neighborhoods with “the third eye” device, the receiving stations will pick-up signals and communicate with parents or families.

Community Benefits

Explain how investigating the problem your team chose will help the community. Be sure to include the impacts your research will have on individuals, businesses, organizations, and the environment in your community (if any). Make it very clear why solving this problem would help your community:

According to the National Crime Information Center (NCIC), over 600,000 US persons went missing in 2018 costing nearly $2B in search and rescue, with our home state Oregon ranking third in the country. We have built a wearable and self-charging device (The Third Eye) that allows families to monitor their loved ones without excessive premiums or recurring expenses.



Our solution benefits Oregon greatly because our state is the third-largest in the United States. Our solution can assist in finding missing children through the use of the GPS tracker, and this will have multiple benefits on our local community, including the lower cost of investigations. It will also have a major emotional benefit, as missing children can have a negative impact on family and friends.

In addition, our solution will allow devices to be charged due to pressure on the piezo pads, thus removing any chance of the GPS running out of battery in the duration of the investigation. Most current solutions do not have this feature, but ours does thus lowering the chance of our solution failing.

To further benefit our communities, we plan to share our ideas with our local police department/sheriff's office and talk to them about distributing our solution to families, aiming to prevent such incidents before they begin. Our aim is to make the device as affordable as possible, as to not let cost discourage families from obtaining our solution.

This solution isn't limited to children, as the piezoelectricity and the GPS aspects of our design are compatible with pets and adults as well, though modifications would need to be made for pets.

We have also conducted presentations in our school and community showing our friends and classmates how our solution works and who it benefits. Our team has become actively involved in this topic and we hope to make a change in our community by raising awareness and continuing to improve our idea.

References

Research your problem. You must learn more about the problem you are trying to solve and also what possible solutions already exist. Find AT LEAST 10 different resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources you can think of. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource:

1. Songsukthawan, Panapong, and Chaiyan Jettanasen. Generation and Storage of Electrical Energy from Piezoelectric Materials - IEEE Conference Publication, IEEE Xplore, June 2017, ieeexplore.ieee.org/document/7992403.
    - This document focuses on the amount of energy generated through piezoelectricity through many tests and simulations. It also discusses ways to store piezoelectric energy for later use. This paper states that piezoelectricity is practical for low-power devices.

2. "Building a Piezoelectric Generator - Activity." TeachEngineering.org, 20 June 2019, www.teachengineering.org/activities/view/uoh_piezo_lesson01_activity1.
    - This source was useful for us because it explained how to wire the piezoelectric pads together. We used this basic circuitry in our final design. It also uses piezo energy to power an LED.

3. *Ou, Brenda. "Piezoelectric Energy Harvesting." Stanford University, large.stanford.edu/courses/2011/ph240/ou1/.*
    - This article lists out multiple facts about piezoelectricity and its current uses and research about it. We used this site to learn more about piezoelectricity and its uses. We also learned about its efficiency and reliability.

4. Howells, Christopher A. "Piezoelectric Energy Harvesting." Energy Conversion and Management, 14 Apr. 2009, www.sciencedirect.com/science/article/pii/S0196890409000697.
    - This was an abstract that gave us a brief overview of piezoelectricity and its uses. It also contained more tests demonstrating the electricity output of piezoelectricity under different circumstances.

5. Staff. "c" Engineering.com, 25 July 2017, www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/15321/Harvesting-Energy-from-Human-Movement.aspx.
    - This article that showed us a new way to harvest human energy, using lithium-ion batteries
      They use black phosphorus nanosheets: A material has become the latest darling of the 2D materials research community because of its attractive electrical, optical and electrochemical properties.

6. Salisbury, David. “Ultrathin Device Harvests Electricity from Human Motion.” *Vanderbilt University*, Vanderbilt University, 21 July 1970, news.vanderbilt.edu/2017/07/21/device-harvests-electricity-human-motion/.

- This article showed us about an existing solution created at Vanderbilt University. This Ultrathin device harvests electricity from human body motion. More specifically electricity generated by arm movements. This article helped us learn more about different body movements that could help generate electricity using piezoelectricity.

7.“10 Human Motion Energy Harvesting Technologies.” *Recent Posts*, 20 Dec. 2012, www.element14.com/community/groups/energy-harvesting-solutions/blog/2012/12/20/different-approach--still-energy-harvesting.

- This article taught us 10 different ways we could generate energy from human motion. From this article, we learned about how piezo devices are used to generate electricity. An example includes a knee joint piezoelectric harvester built by a team of UK researchers from the University of Salford, University of Liverpool, and Cranfield University.

8. Stern, Becky. “GPS Logging Dog Harness.” *Adafruit Learning System*, 4 June 2014, learn.adafruit.com/gps-logging-dog-harness.

- This article showed us how the Adafruit GPS tracker works. We saw the writer of the article track where she and her dog walked. It also showed a step by step process of tracking the dog through Google Maps. This article really gave us an insight into how the GPS tracker worked.

9. Blums, Juris, et al. “Wearable Human Motion and Heat Energy Harvesting System with Power Management.” *IntechOpen*, IntechOpen, 27 June 2018, Cc.

- This article talks about the analysis of electromotive force and energy generated in inductive elements inhomogeneous magnetic fields. It also talks about the definition and how to use voltage to harvest energy.

10. Blums, Juris, et al. “SEQUENT WATCH: the World's First Self-Charging Smartwatch.” *Kickstarter*, Intechopen, 24 Sept. 2019, www.kickstarter.com/projects/sequent-world/sequent-the-worlds-first-kinetic-self-charging-sma.

- This article talks about a self-charging watch. This watch is based on a traditional Swiss automatic watch movement. Just like piezoelectricity it generates kinetic energy to electrical energy. But we didn’t think this technology would help us create a good solution to our problem.

11. Editors, MIT TR. “Low-Power GPS.” *MIT Technology Review*, MIT Technology Review, 30 Dec. 2013, www.technologyreview.com/s/410339/low-power-gps/.

- This article showed us how a low powered GPS works. This article really shows us the technology of a Low Powered GPS at a detailed level.

12."GoFindMe: A GPS Tracker Works Without Cell Service." Translated by GoFindMe, *Indiegogo*, 29 Oct. 2019, www.indiegogo.com/projects/gofindme-a-gps-tracker-works-without-cell-service#/.

- This article showed another existing solution of a GPS tracker that tracks without any cell service and monthly fees. From this solution, we decided that our solution should work offline and because it is self-charging it should not have any monthly fees.

13. Edwards, Rebecca, and Rebecca Edwards. "10 Best Kids GPS Trackers and Devices of 2020." *SafeWise*, 17 Feb. 2020, www.safewise.com/resources/wearable-gps-tracking-devices-for-kids-guide/.

- This website shows us different types of wearable GPS trackers for kids. This gave us another insight into already existing solutions. Again we found that none of these are self-charging.

14."GPS Tracking for Birds - Extremely Lightweight Remote Data." *Telemetry Solutions - Specializing in Micro GPS for Wildlife Tracking*, 2017, www.telemetrysolutions.com/wildlife-tracking-devices/gps-backpacks/nano-backpacks/.

- This article showed us a nano GPS tracker that is used to track birds.

15. "SKYLEADER 2 GPS Pigeon Tracker Ring 5 Port Package." WINCASER, 23 Apr. 2017,

- www.wincaser.com/skyleader-2-gps-pigeon-tracker-ring-5-port-package?gclid=CjwKCAiAvonyBRB7EiwAadauqS-P2qlfrmDk16a7CfBAh9FSuWvTvjPrP5hFOvzbeTq15POVcfH3lBoCGAwQAvD_BwE.
    - This website showed us a SKYLEADER 2 GPS Pigeon Tracker Ring 5 Port Package that was on sale. This showed us another existing solution.

16. *National Crime Information Center (NCIC) - FBI Information Systems*, NCIC, fas.org/irp/agency/doj/fbi/is/ncic.htm.

This site is created by the NCIC. From this site, we got a lot of our statistics like the number of missing people in Oregon and how Oregon is third on the list of the state with the most missing people.