NavStraps

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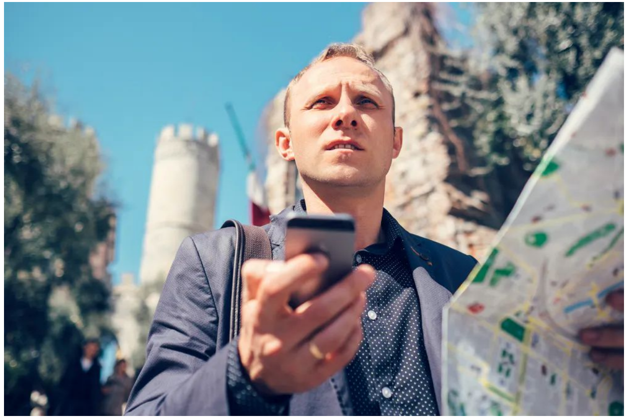
Project Problem Definition

Problem Statement: Current methods of pedestrian navigation, including maps and phone applications are inadequate, because they restrict situational awareness and draw the pedestrian's attention excessively.



Project Scope and Objectives

Our project is a proof of concept that we can link a navigation system with our software. The initial idea for this project was to be able to connect to Google's API. Due to lack of licensing and funding, our group was unable to meet this standard, so our demo simply demonstrates how the NavStraps would work if connected to Google's API.

Our project scope primarily includes the hardware and software of the NavStrap itself. Given time and resources, the NavStrap could be connected to a user's smartphone GPS, with all additional programming performed on the side of the smartphone device. No modifications to the device would be necessary.

Analysis of Alternatives

Four Main Solution Ideas:

- Wristbands
- Belt
- Pocket Insert
- Glasses

Criteria	% Weighted	Bracelet	Belt	Pocket Insert	Glasses
Directions	0.33	5	5	2	4
Eyes/Ears Available	0.27	5	5	5	3
Individual Alert	0.20	5	4	5	3
Ease of Use	0.07	4	2	3	3
Weight	0.00	0	0	0	0
Battery Life	0.13	2	4	3	1
		4.53	4.47	3.60	3.07

Comparing and Analyzing:

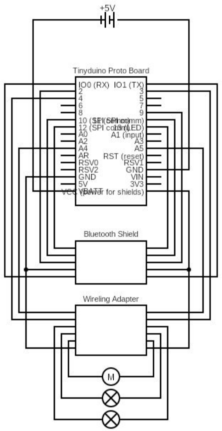
- When comparing all four of the main solutions, 6 different criteria were used to determine each solution’s viability. These criteria were:
  - Directions, Eyes/Ears Availability, Individual Alert, Ease of Use, Weight and Battery Life
- Used a likert scale and solution matrix to narrow down the list of solutions to single idea

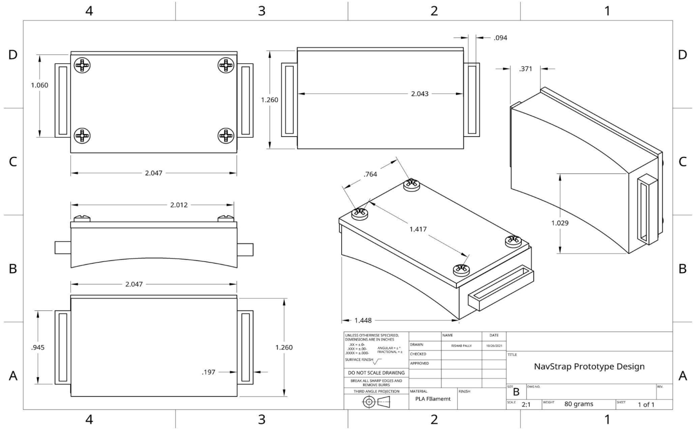
Requirements and Design Space Analysis

- Overall Functional Requirements
  - Needs to indicate the user to turn left/right
  - Alerts need to be subtle and not distracting
  - Allows user to be more aware of his surroundings (increases overall situational awareness with having eyes and ears available)
  - Compact and wearable on hands
- Specific Design Requirements
  - Vibration to alert the user
    - Left will be indicated by a buzz/vibration on the left hand
    - Right will be indicated by a buzz/vibration on the right hand
    - Both sides will buzz/vibrate on arrival at destination
  - All electronic components will be placed inside two cases with straps
    - One case will be placed on the left hand and the other will be placed on the right
    - Components will be very small and the casing will be able to support all parts
  - Bluetooth connectivity
  - Led to indicate different states
- Most Critical Design Requirements
  - Buzzers will be placed inside of the casing to create a set mode vibration indicating the user to turn left, right or arrival of destination
  - Creating casing using CAD software
  - Programming of the LED and motor will be transduced through a smaller Arduino board(TinyDuino board)
  - Cable management will be all inside the case
  - Bluetooth Connectivity will be provided through a mobile application(NRF Connect) which enables us to have two functioning channels

Design Selection

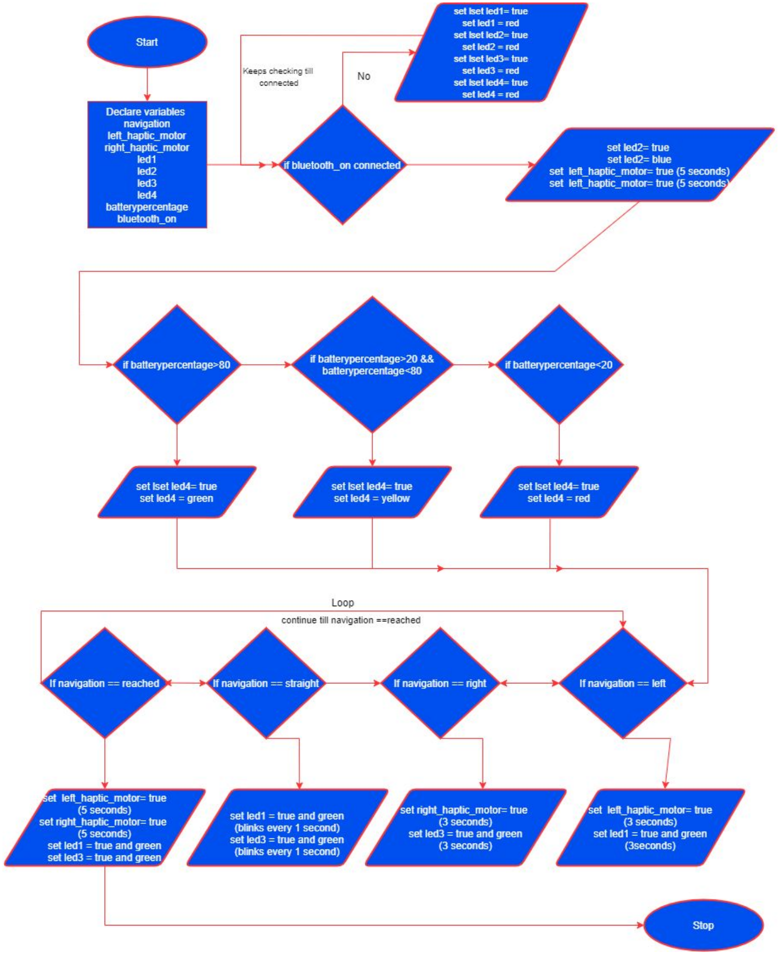
- For our design, we went with two wristbands designed using CAD. The casing for the buzzer, light and circuit boards was composed of a container and a lid that would comfortably fit on the average wrist.
- In order to fit all the needed components into the small 5.2 cm by 3.5 cm case, something other than a normal arduino was needed. A product called “Tinyduino”, that creates mini circuit boards about the size of a quarter were able to fit in the casing and were ideal for the project.





Software Flowchart

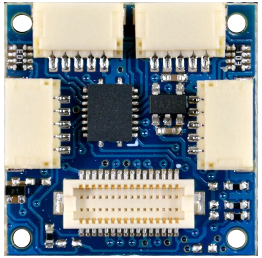
- Initial Flowchart
  - Bluetooth Connectivity showing (connected)
  - Battery Percentage(shown using RGB LED)
  - Left buzzer for left navigated direction
  - Right buzzer for right navigated direction
  - Both will buzz on arrival on destination
- Updated Flowchart
  - Bluetooth Connectivity (Connected/ Disconnected/Losing Connectivity)
  - Battery Percentage voided due to lack of Tinyduino limited libraries
  - Left buzzer for left navigated direction (time limit with additional prebuilt vibration @ mode 82)
  - Right buzzer for right navigated direction (time limit with additional prebuilt vibration @ mode 82)
  - Both will buzz on arrival on destination (time limit with additional prebuilt vibration @ mode 82)

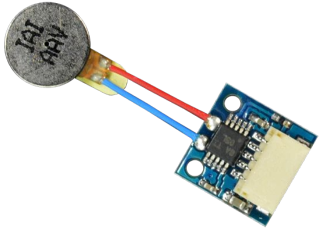


Circuit Board Components

PROCESSOR BOARD

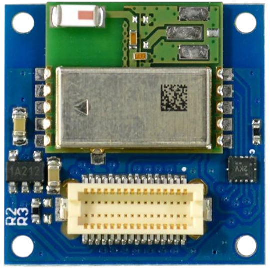
WIRELING ADAPTER





LRA DRIVER WIRELING

BLUETOOTH SHIELD



LITHIUM ION POLYMER BATTERY - 3.7V 150MAH

RGB LED WIRELING

Material Selection

- Initial material selection: 3003 grade aluminium.
  - Advantages
    - Material holds a higher yield strength and is very durable.
  - Disadvantages
    - Sits heavy on the wrist
    - Heat dissipated at a slightly higher rates
    - Not comfortable on skin.
    - Aluminum casing is too dense/thick therefore the buzzer’s effects were not transmitting through
- Material Used: PLA filament
  - Light on the wrist
  - Vibrations by buzzer transmitted through casing
  - Durable

Risk Analysis of Selected Design

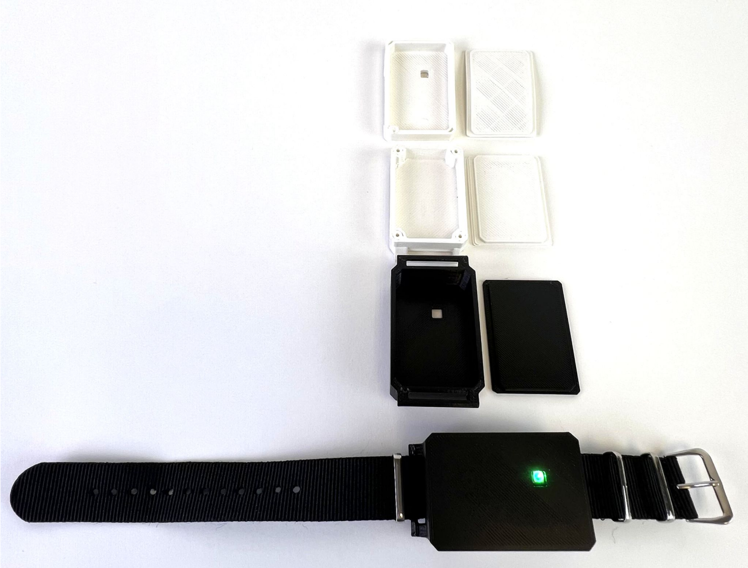
- Wristband Risks
  - Battery life
    - This risk was minimized by using a rechargeable battery from Tinyduino that was relatively small but still maintained sufficient power.
  - Insufficient buzz from motor
    - This risk was also minimized by using the LRA Driver Wireling from Tinyduino which included 117 preprogrammed buzzes, enabling us to choose the most powerful, effective buzz.
  - Size
    - Potentially unable to fit on wrist while containing all necessary components.

Risk Mitigation

- Bluetooth connection does not work
  - Rather than attempting to prototype using a custom PCB, we are using the TinyDuino Bluetooth Low Energy Shield, based on proven Arduino technology
  - Another possible alternative would be radio communication
- Hardware becomes non-functional due to too much voltage or other human errors
  - We will use a full-sized Arduino to prototype and verify the concept and software before moving to the smaller and more fragile TinyDuino
- Casing is improperly sized to fit hardware
  - Casing is CAD modeled using variables, so that it can rapidly be resized if hardware demands change

Manufacturing

- Design
  - We had an initial CAD prototype for the casing of the watch
  - A second design was constructed that solved most of the problems with the first iteration
- 3D Printing
  - Both the prototype and the final product were 3D printed
  - 3D printing material was relatively inexpensive so this allowed for multiple builds and redos
- Soldering
  - Soldering was initially thought to be an essential tool for connecting the Tinyduino circuits together but turned out to be unnecessary
- Finalizing the Build
  - After printing out the case, we managed to fit in both the TinyDuino stacked circuit boards and the battery. We set the frictionless set lid on the bottom which is held by nato straps making all the components in the casing secure

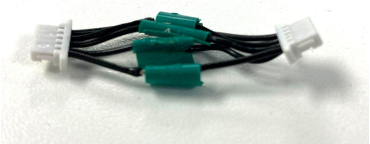


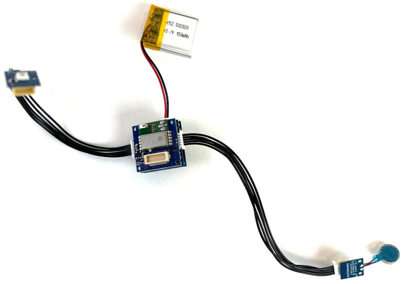
Testing and Analysis

- Preliminary Testing
  - Determined that bluetooth could be incorporated into a regular sized arduino and commands could be sent via smartphone
- Phase 1
  - This involved moving to the Tinyduino boards and uploading basic code onto the processor board
  - The LED light, buzzer and bluetooth shield were all tested separately to check how they operated
- Phase 2
  - The next step involved getting the bluetooth command to modify a variable in the code so that the LED's color could be changed remotely
- Phase 3
  - The final testing phase included getting the bluetooth command to buzz the motor and turn on the light. Getting each of the separate bracelets to connect to the same phone was also an objective of this phase.

Testing Setbacks

- Wiring
  - The wires for connecting the light and motor to the circuits was unnecessarily long so we attempted to cut them to a shorter size and solder them back together. Unfortunately, the revised wires were unable to pass electricity between the board and the components so we gave up.
- Initial Case
  - The initial case size that was 3D printed turned out to be too small to fit all the components inside.
- Coding
  - The coding was the most difficult part of the whole project. At the beginning we had no idea how to even upload the code to the Tinyduino because we were missing some libraries.



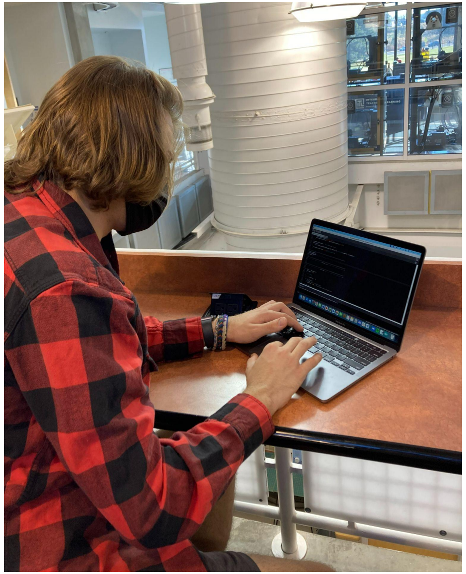


Improvements and Future Iterations

- ❖ New Slim Design
  - ➢ Reduce bulky design
  - ➢ Wiring/ Cable management needs to be improved
  - ➢ Possible new variation and more optima design
- ❖ Bluetooth connectivity
  - ➢ Be able to shift from left NavStrap to right Navstrap seamlessly
  - ➢ Channel both devices on one connection
- ❖ TinyDuino vs. Arduino
  - ➢ TinyDuino does not have standard code
  - ➢ Many functionalities are limited
  - ➢ Use different type of compact arduino board

Conclusion / Team Growth

- **New skills acquired or improved on**
  - CAD designing
  - Arduino Coding and Syntax
  - 3D Printing
  - Electric Work(wiring, soldering, etc.)
- **Effective communication**
  - Setting up different forms of electronic communication(Email, Phone/Text, Slack, GroupMe, etc.)
  - Brainstorming efficiently(Miro, Trello)
- **Time management**
  - Advanced Planning System(Google Calendar)
  - Assigning Tasks and Discussing Objectives beforehand
  - Scheduling around internal and external obstacles
- **Collaborative work**
  - Efficiency/ Work Integration
  - Area of Strengths/Weaknesses Identified
  - Professionalism
- **Build stronger relationships**
  - Work together outside terms of project
  - Socialize after hours
- **Active Listening**
  - Idea Contribution
  - Voicing concerns
- **Taking responsibility**
  - Even contributions
  - Meeting team objectives and requirements

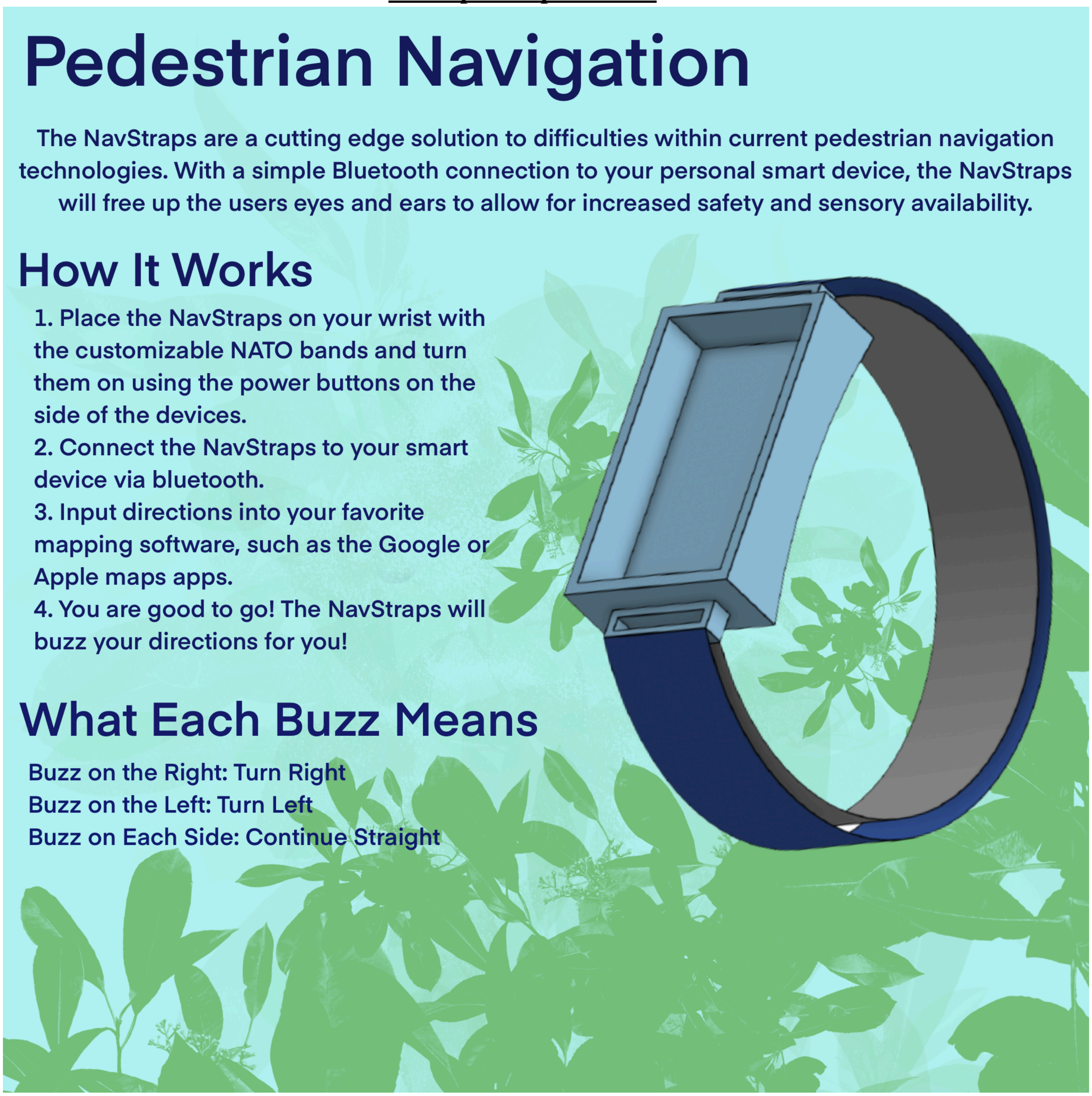


Critical Design Review
Team 6

Oliver Barwell, Charlie Peabody, Rishab Pally, Noah Schakel, Zack Goldberg

NavStraps™ ***Stay strapped***

Concept of Operations:



Technical Drawings:

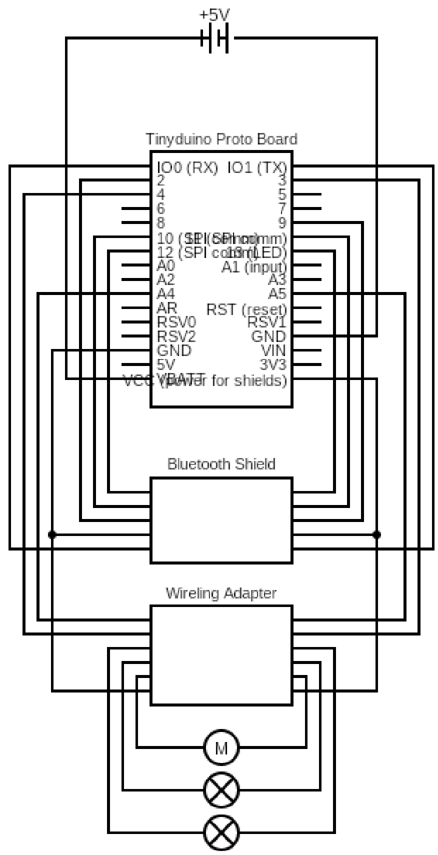


Figure 1 - Electrical Wiring Diagram

The power for this setup is supplied by a 3.7 V Lithium-Polymer battery. The wireling adapter on the diagram connects the haptic vibrator and led RGB lights to the processing board without any soldering. The bluetooth shield should be able to connect to a smartphone through the BLE scanner app.

Tech Specs:

RGB Light:

- Voltage:
  - 3.0 V - 5.5 V
- Current:
  - Red: 30mA
  - Green: 20mA
  - Blue: 30mA
  - White: 65mA

Wireling Buzzer

- Voltage:
  - 3.0 V - 5.5 V
- Current:
  - 2.5 mA

Bluetooth

- Voltage:
  - 3.0 V - 5.5 V
- Current:
  - Transmit: 10.9 mA
  - Receive: 7.3 mA

Figure 2 - Component Connection Diagram

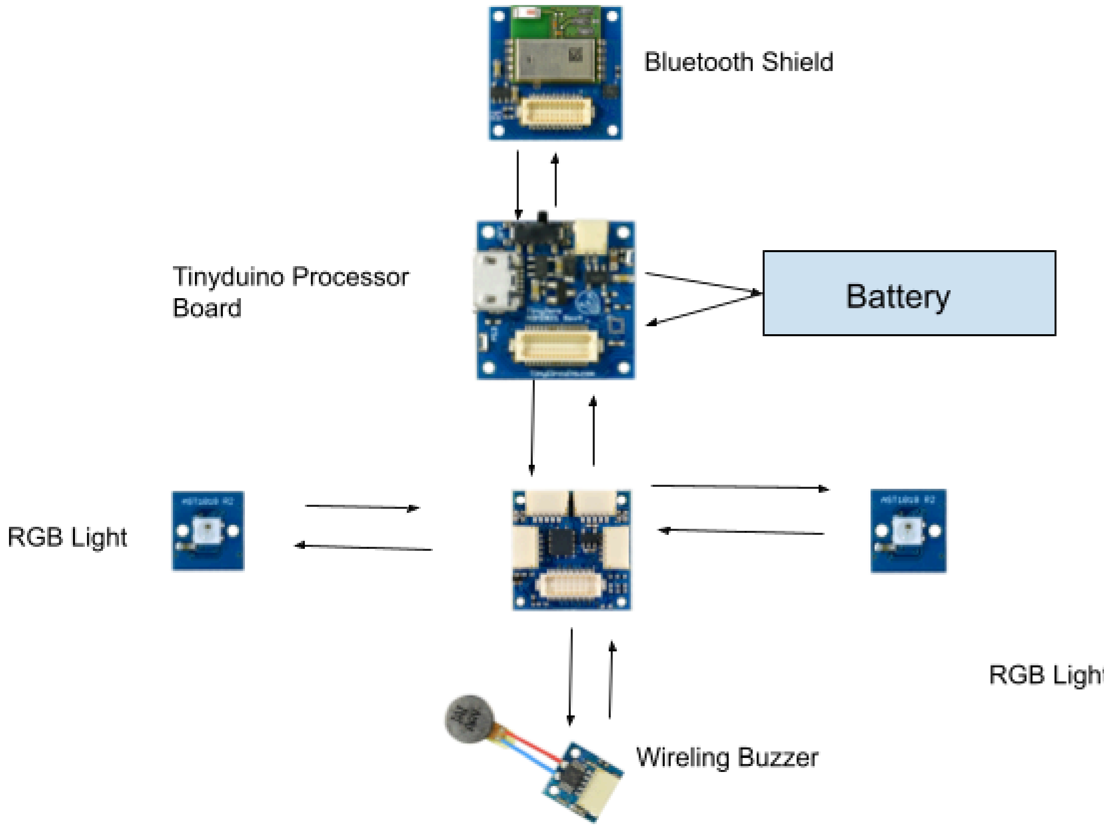


Figure 3 - **150 mAh rechargeable lithium polymer battery**

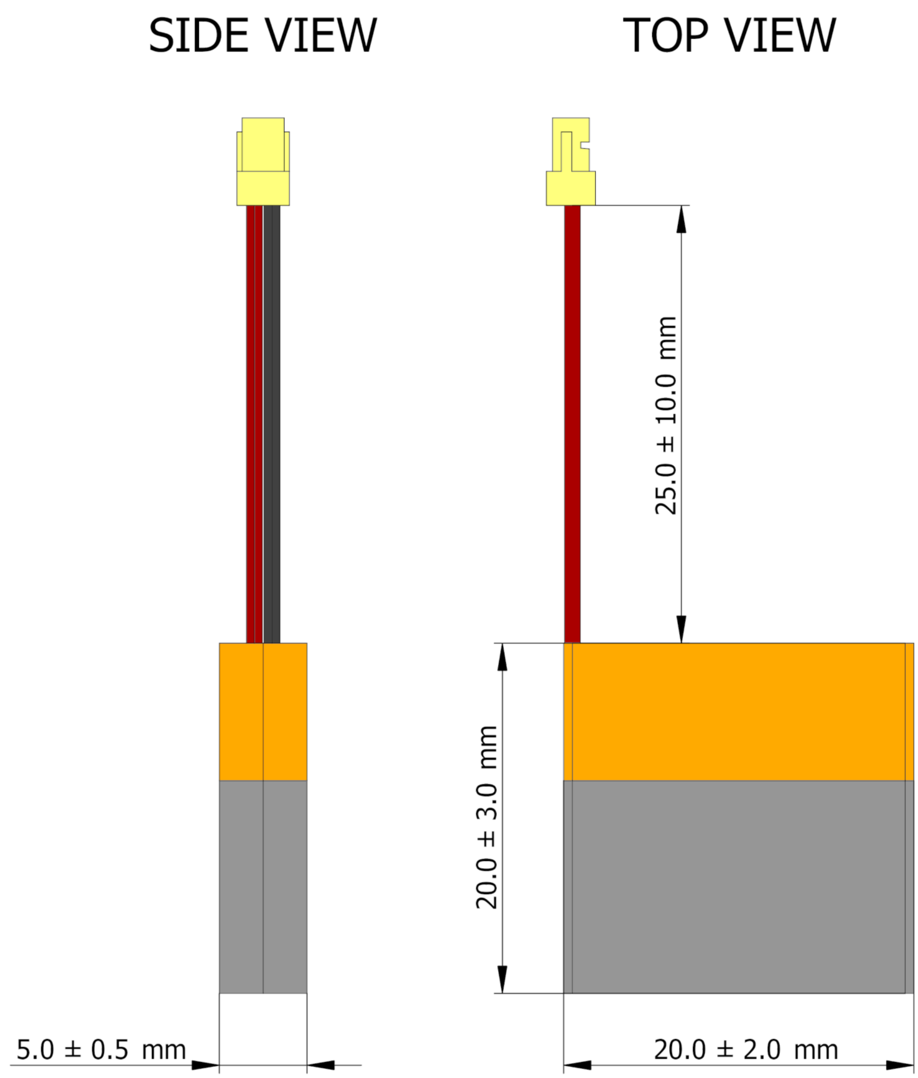


***Figure 4* - TinyDuino Processor Board**

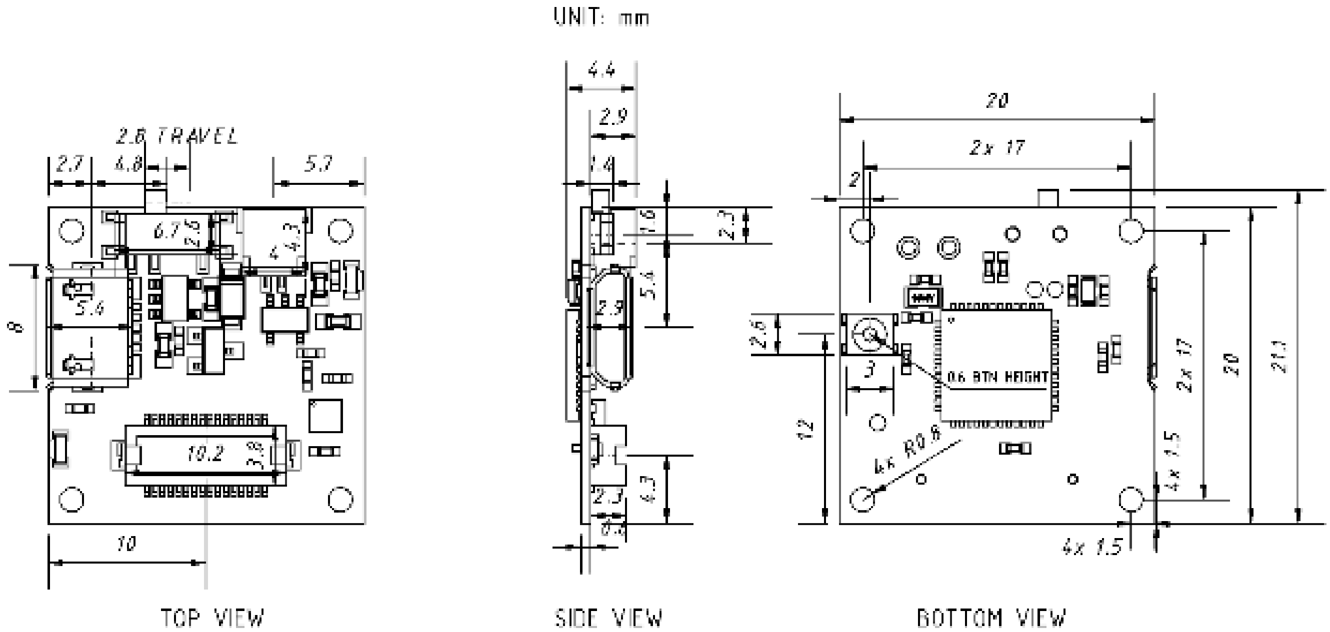


***Figure 5* - TinyDuino Bluetooth Shield**

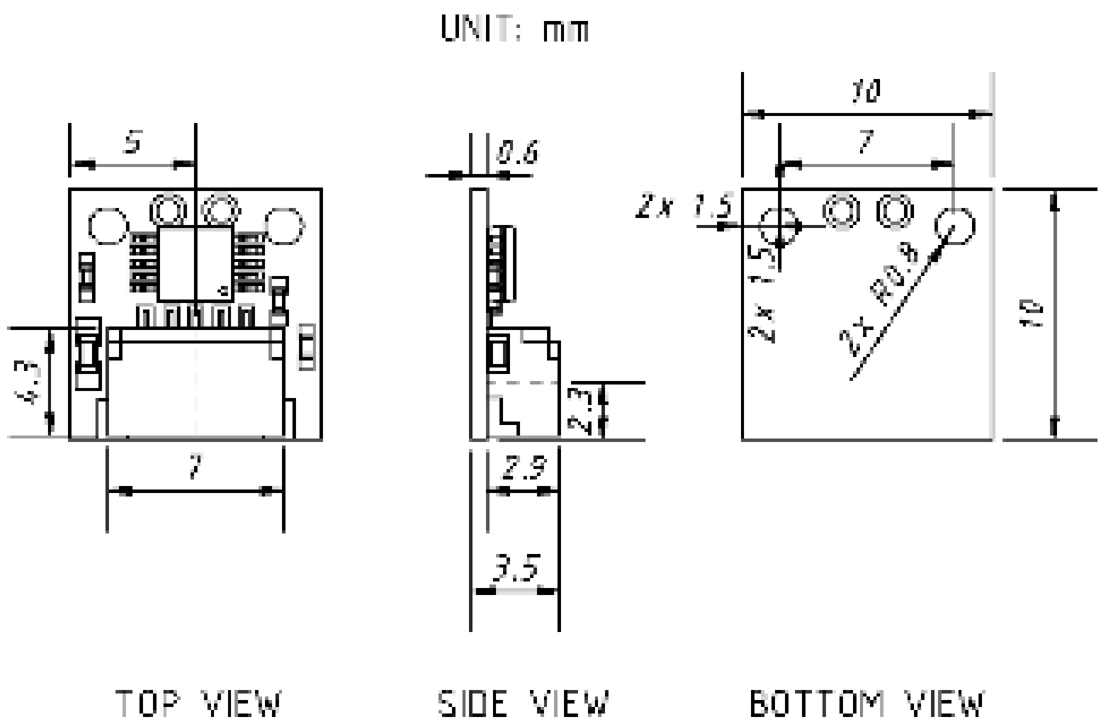


Figure 6 - **TinyDuino Proto-Board**

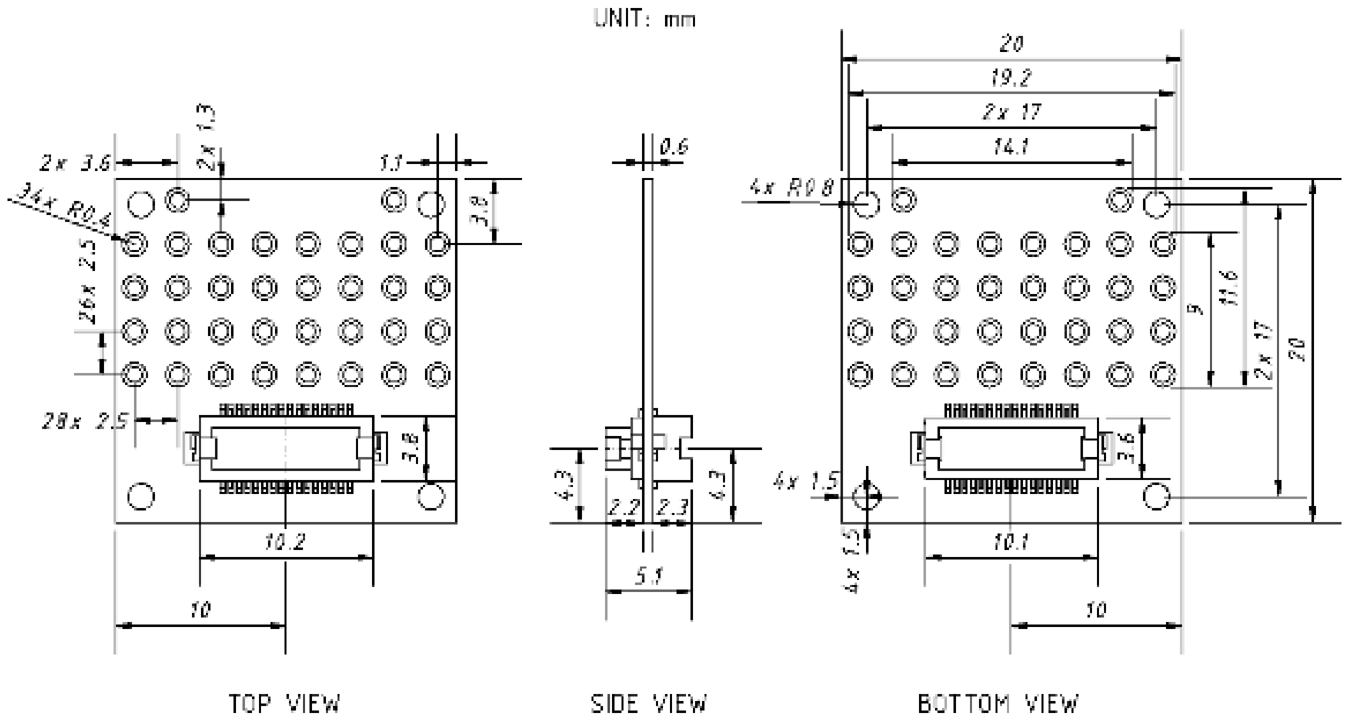


Figure 7 - **TinyDuino LED Integrated Board**

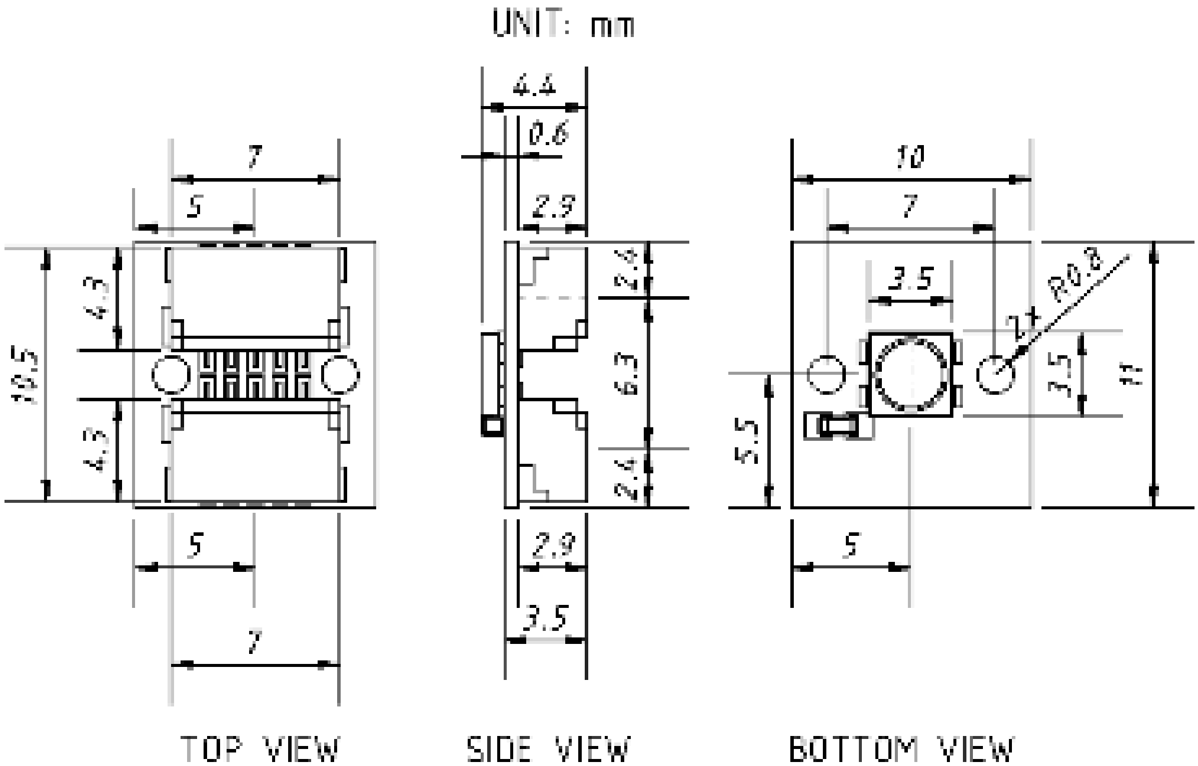


Figure 8 - **TinyDuino Buzzer Connection Board**

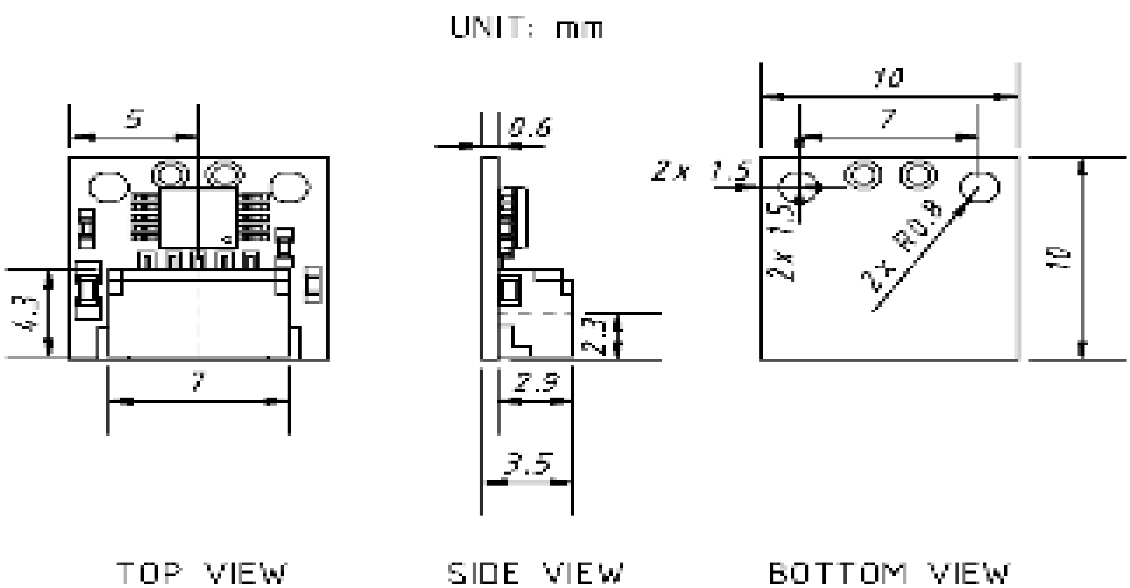


Figure 9 - **NavStrap Prototype 2D Export**

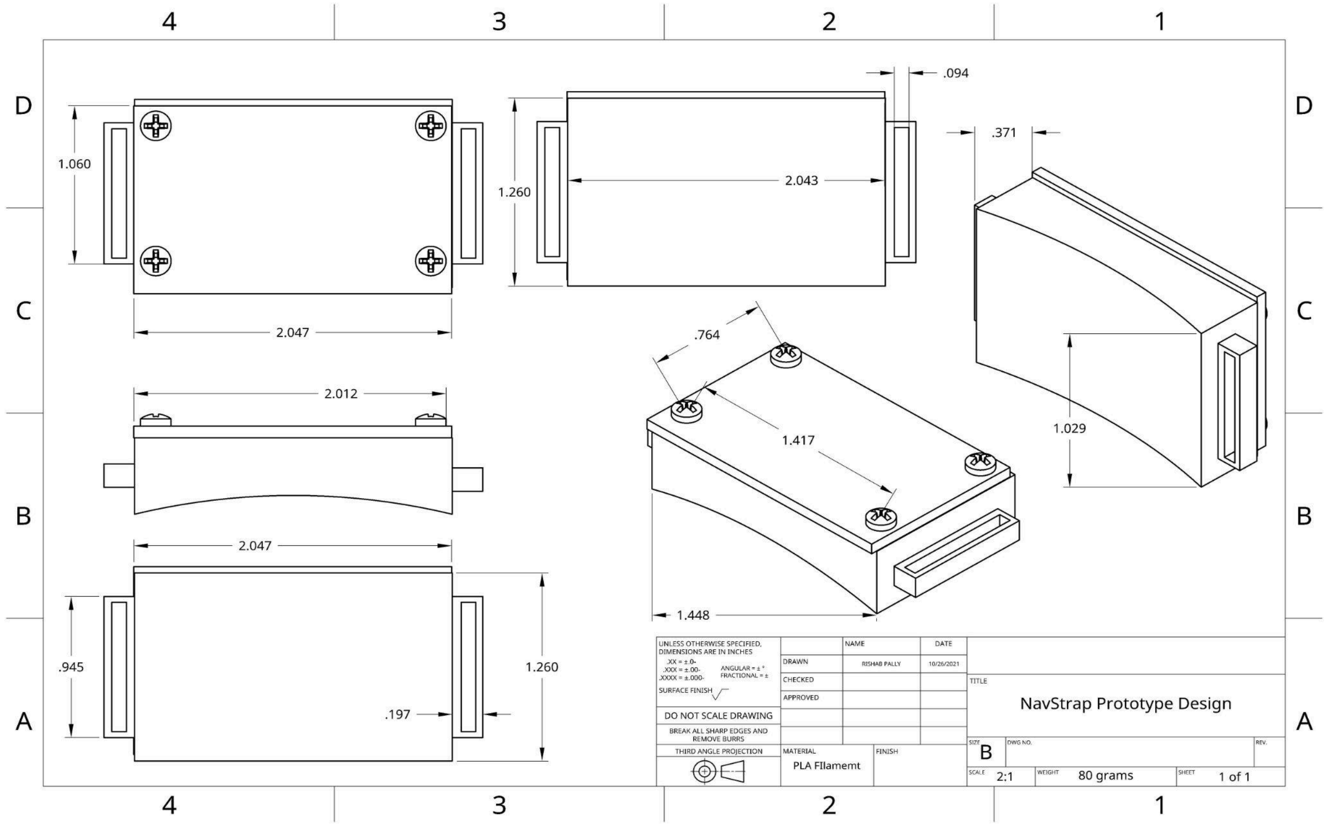


Figure 10 - **Expanded view of internal hardware components**

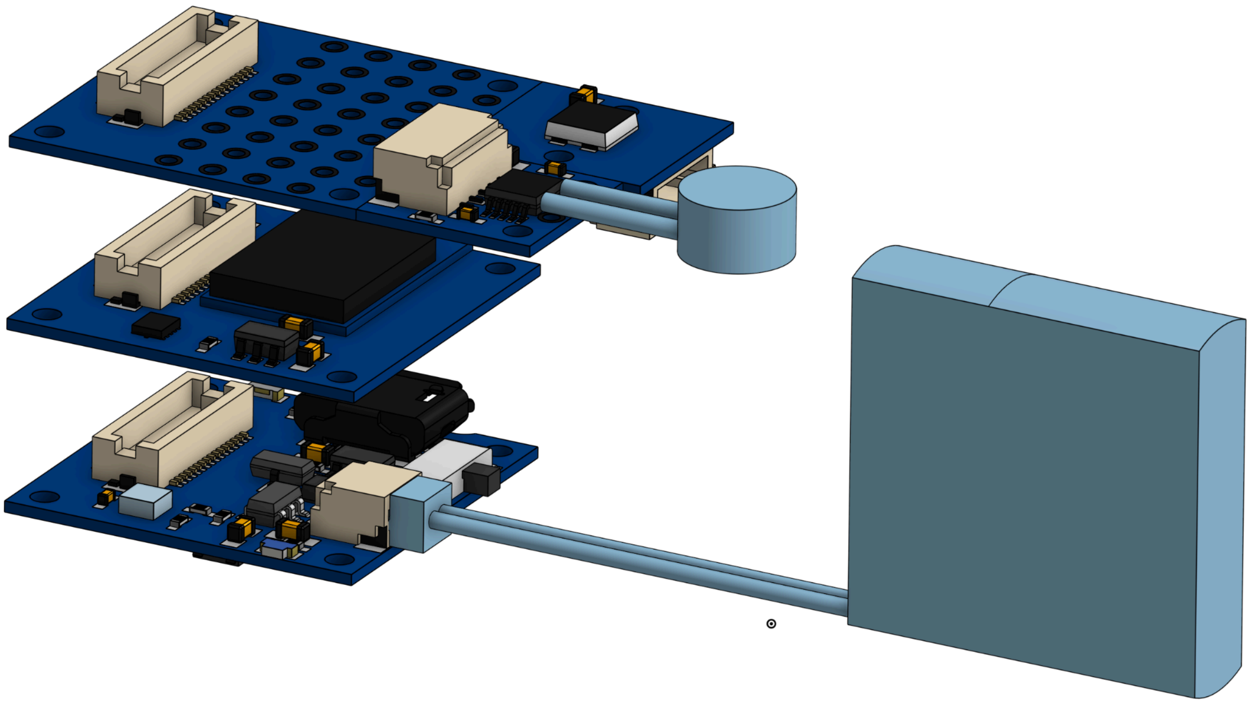


Figure 11 - **Housing with transparent lid**

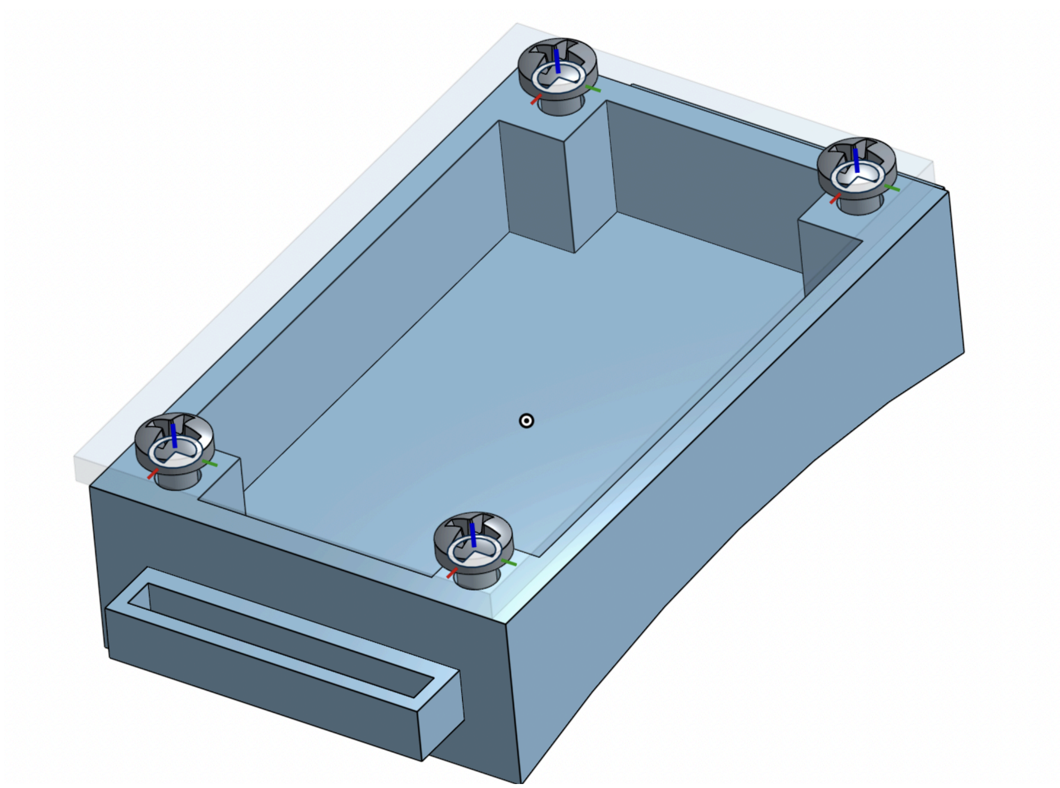


Figure 12 - **Expanded view with housing and circuits**

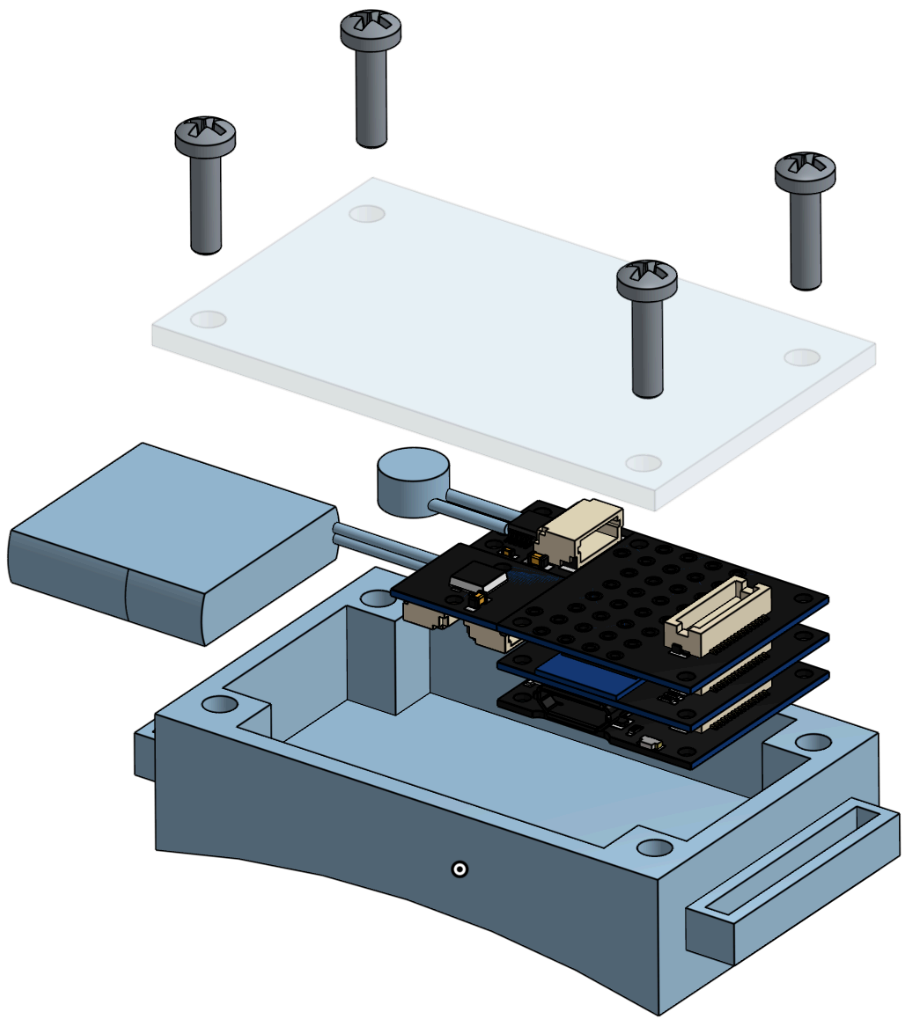
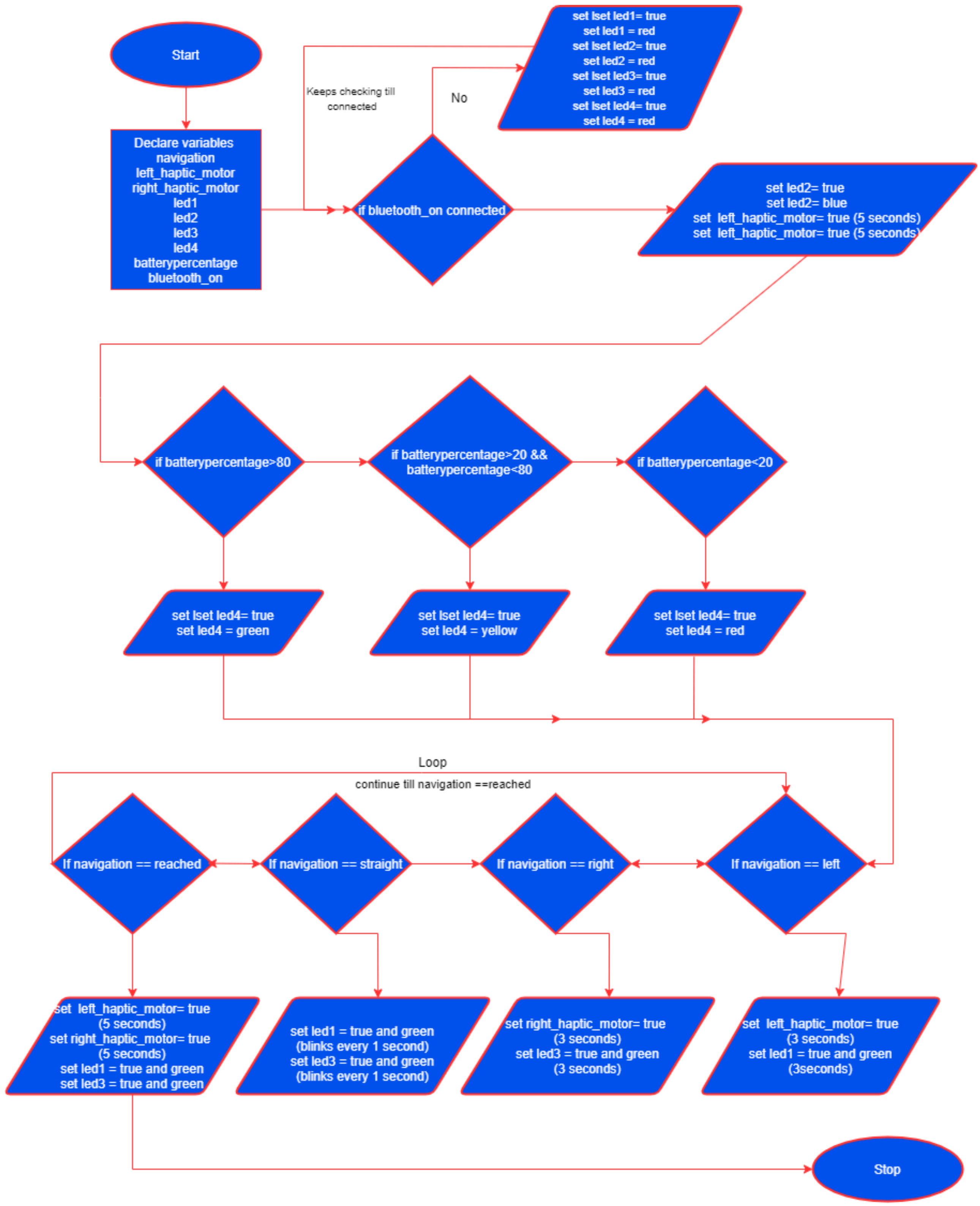


Figure 13 - **Programming Flowchart Diagram**



Critical Project Elements & Risk Mitigation:

Critical Project elements:

- TinyDuino
  - The TinyDuino board is the core of the project. It provides equivalent processing power to an Arduino Uno, in a compact, 20x20mm package, suitable for a wrist strap.
- Bluetooth Connection
  - A bluetooth connection will be used to connect the TinyDuino to a phone or computer.
- Hardware-software integration
  - Our hardware and software must work properly with little-to-no user intervention or maintenance.
- TinyDuino Rechargeable Lithium Ion Polymer Battery
  - This small compact rechargeable battery is charging up our system. This small package comes with 3.7 V at a capacity of 150 mAh.
- RGB Lights
  - These small LEDs produce various 24-bit resolution colors. This component can be programmed by connecting to the TinyDuino boards and comes with various combinations.
- Driver Wireling
  - This is a Haptic driver chip, and the Wireling lets us control the motor. Using the Wireling, we can create haptic motor vibration effects.

Risk Mitigation:

- Bluetooth connection does not work
  - Rather than attempting to prototype using a custom PCB, we are using the TinyDuino Bluetooth Low Energy Shield, based on proven Arduino technology.
- Hardware becomes non-functional due to too much voltage or other human errors
  - We will use a full-sized Arduino to prototype and verify the concept and software before moving to the smaller and more fragile TinyDuino
- Casing is improperly sized to fit hardware
  - Casing is CAD modeled using variables, so that it can rapidly be resized if hardware demands change

Validation & Testing:

Preliminary testing:

Preliminary testing is simply a functional proof of concept utilizing an Arduino Uno board to prototype the device and test the feedback hardware components as well as the software elements in a more modular environment. The Arduino Uno board allows for a better iteration process as a preliminary circuit will be created and then the continuous addition of components and code can occur allowing for a more modular prototyping process. Once the Arduino Uno prototype resembles the circuit that reflects the wiring diagram, with functioning buzzers, bluetooth connection LED, and Battery output LED, the project will enter the testing phase utilizing TinyDuino board components to downsize the project.

Phase I:

Phase one of testing will consist of general assembly of TinyDuino components and multimeter measurements to ensure that all components are receiving the correct voltage, and no shorts and/or gaps in the circuits are present. This phase will also include a basic function test of each individual component to ensure that the desired outputs of Vibrations, Lights, and Bluetooth Signal can be achieved.

Phase II:

Phase two of testing will consist of basic code testing using a hardwired system to the computer. The main functions of Battery Level Indication, and Left, Right, and Straight Vibration Signals will be tested and confirmed.

Phase III:

Phase three entails the wireless testing portion where the Bluetooth transceiver's range and strength will be tested. Within the bluetooth testing, pseudo-signals from a smartphone will be transmitted over bluetooth to test and prove the feasibility of smartphone navigation app communication with the navigation device. After bluetooth connectivity is tested and confirmed, the tinyduino device will be installed in its housing. This phase also encompasses human trials for general feedback on the device's haptic signals, weight, and ease of use, and overall conspicuousness. Human subjects will consist of the development team initially.

Phase IV:

The final phase of testing will consist of a simulation of real-world applications. Using a third-party human subject to act as the end user, we will run three tests. The first trial will have the subject navigate through a predetermined route using a pre-programmed series of device outputs, with no bluetooth connection. This trial verifies the ability of the device to convey intuitive and actionable information to the end user.

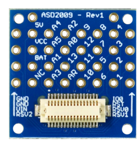
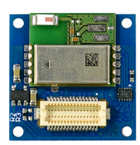
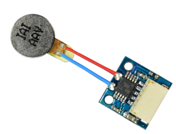
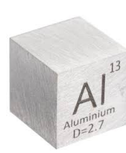
The second trial will utilize the navigation device's bluetooth connection, allowing the development team to direct the user manually through a new course. This trial further tests the navigation device's ability to overcome signal interference from obstacles, as well as test the limits of the bluetooth connection's range, strength, and signal travel time.

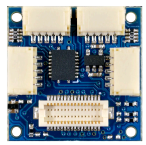
The third trial will utilize a smartphone placed on the user to transmit a premade script of navigation signals to traverse the user through a new course, independent of the development team's interaction with the user or navigation device. This trial is a practical test of the entire system to prove the ability of the device to direct a user, utilizing signals transmitted wirelessly from a smartphone.

Project Planning

Design Process	**Programming**	**Hardware**	**Final Project**
CAD Model	Get code to receive bluetooth input	Prototype basic electronic setup with regular sized arduino kit	Final report/presentation
Electric Diagram	Get code to turn on buzzer based off of bluetooth input	3-d print casing for the electric components	Both bracelets fully functional, able to buzz on command/ with LED functionalities
Programming Flow Chart	Get code to turn on/off led lights based on power and bluetooth connectivity	Build the entire system with the tinyduino and wire it up so it connects with bluetooth	Have a possible live demonstration using command by command directional functions
		Make sure electronics and casing fit together	
		CNC the final casing out of aluminum	

Components & Cost:

Material Name	Material Image	Number of Materials	Cost
TinyDuino Processor board		2	$29.95
TinyDuino Proto-board		2	
TinyDuino Rechargeable Lithium Ion Polymer Battery		2	
Tinyduino Bluetooth Shield		2	$29.95
Driver Wireling		2	$14.95
PLA Filament for First Iteration of Housing		1	$19.95
Aluminum for Final Iteration of Housing		1	$2.00

RGB Light		5	$7.95
Wireling Adapter		2	$19.90
5 pin Wireling Cable 100mm		10	$5.99
Total Cost			**$130.64**

Summary of Consultant Review - Jonah Spicher

Wiring - In Jonah's experience, wiring and components for small-size projects such as this one take up more space than expected. He warned that if we just consider the part sizes, and not how everything fits together, we will have a hard time fitting everything into our housing. He told us that it is a good idea to lay out our components and see how we can fit them together and be able to adjust our CAD file to correctly fit everything.

Bluetooth - Jonah said that the bluetooth component of our device may have a few issues, but as TinyDuino and Arduino as a whole are rather reliable so he did not think this would be a major issue. It may require some tweaking and debugging, however he is confident in our ability to get the bluetooth connection to function. Should we not be able to get bluetooth to work, he informed us that Mo Woods has some experience with RF transmission, which would be our next choice.

Vibration Motor - Our plan for the vibration motor is to fix it to the housing of the device, in order to get as much vibration to the user as possible, which Jonah agreed was a good idea. He verified that our battery, which is 150mAh, would be able to power the motor, which is a 2.5 mAh motor.

Overall, Jonah had confidence in our ability to be able to move forward with our project, and did not see anything that jumped out to him as an obvious red flag in our CDR.