Critical Design Review
Team 6

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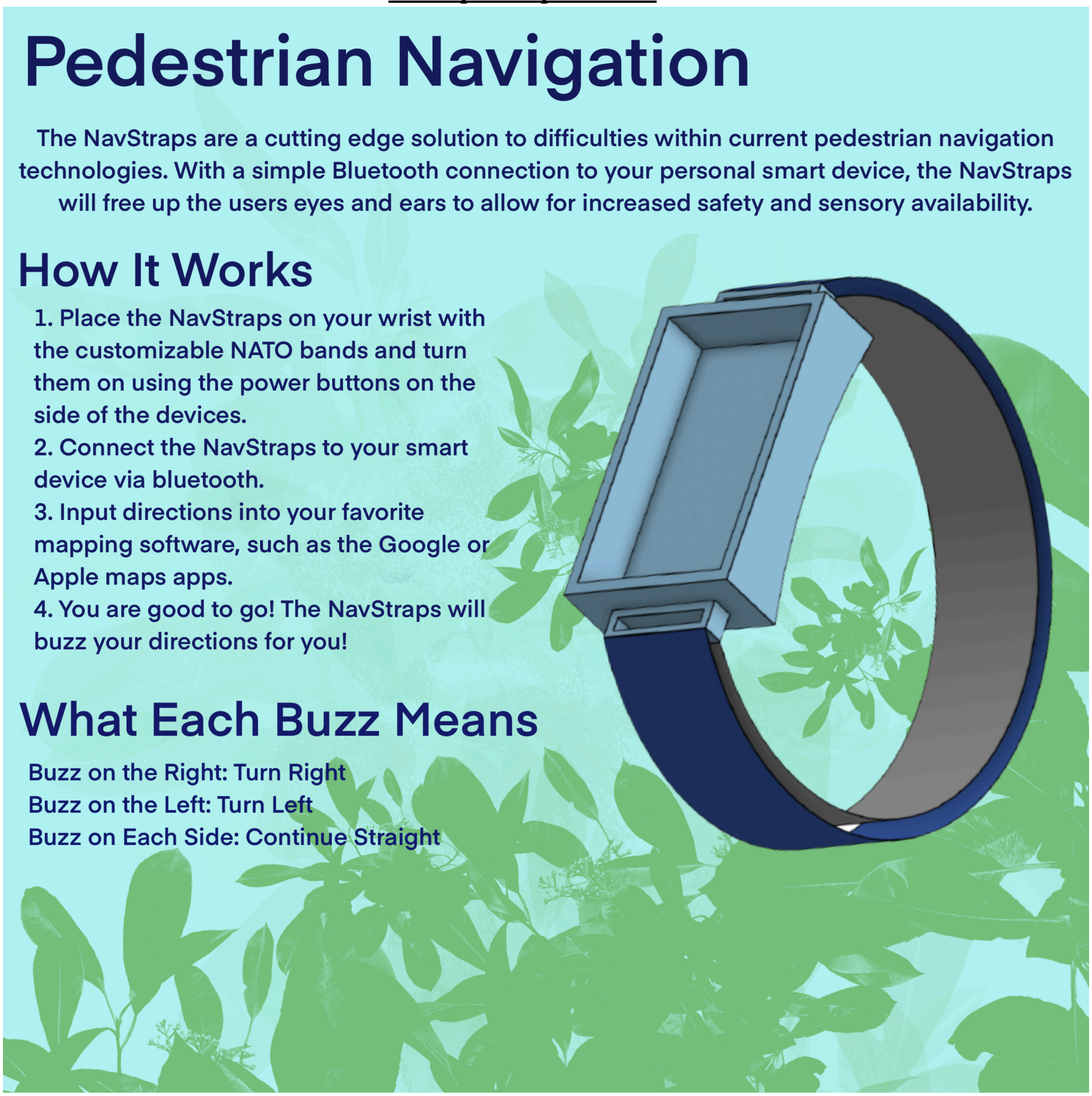
NavStraps™ ***Stay strapped***

<u>Concept of Operations:</u>



Technical Drawings:

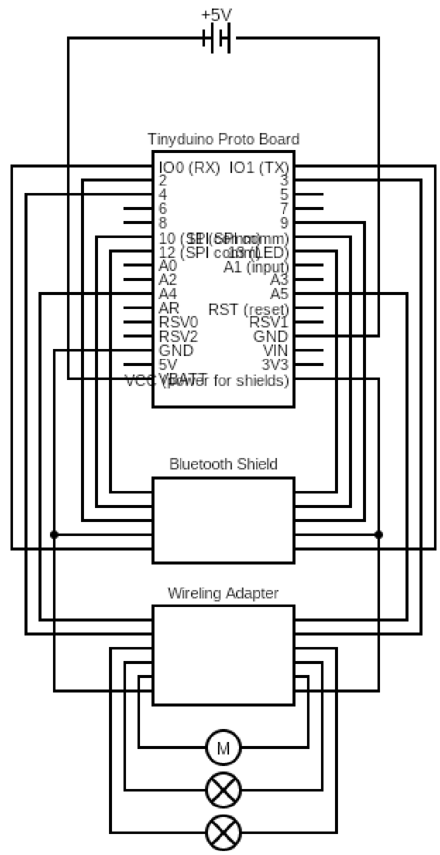


Figure 1 - Electrical Wiring Diagram

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

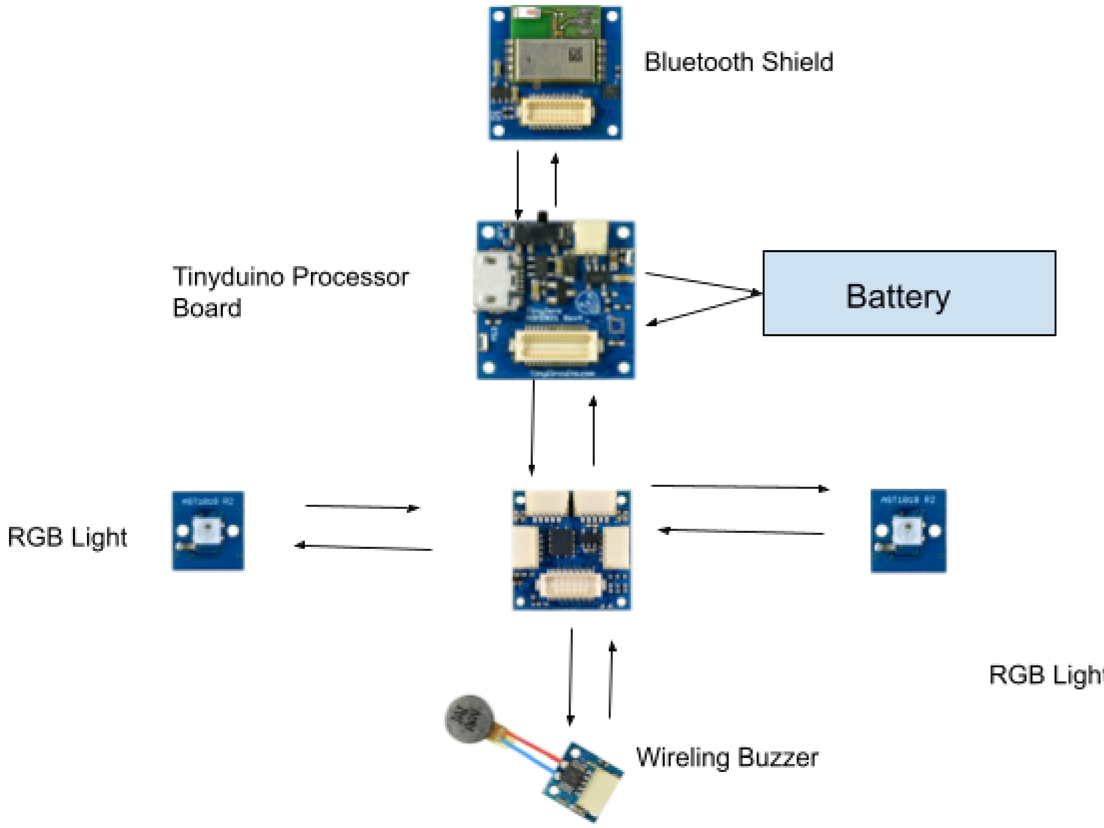


***Figure 3* - 150 mAh rechargeable lithium polymer battery**

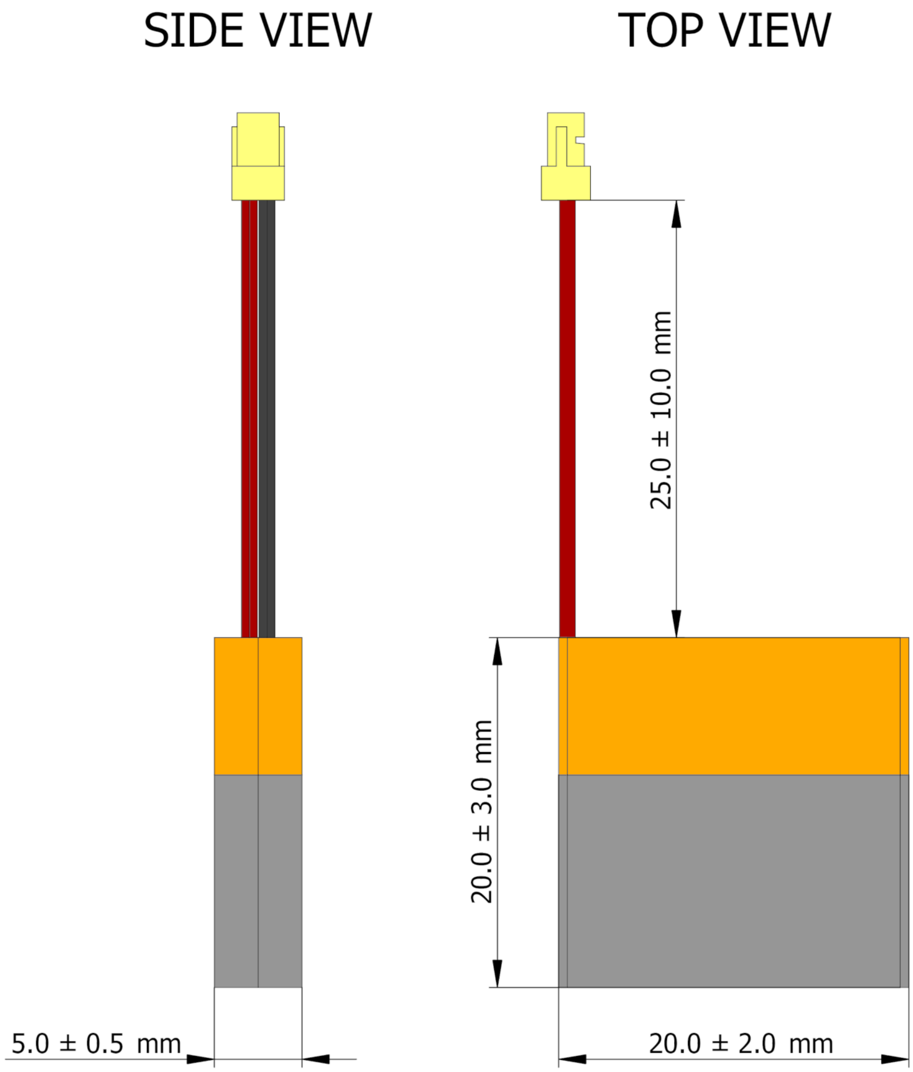


Figure 4 - **TinyDuino Processor Board**

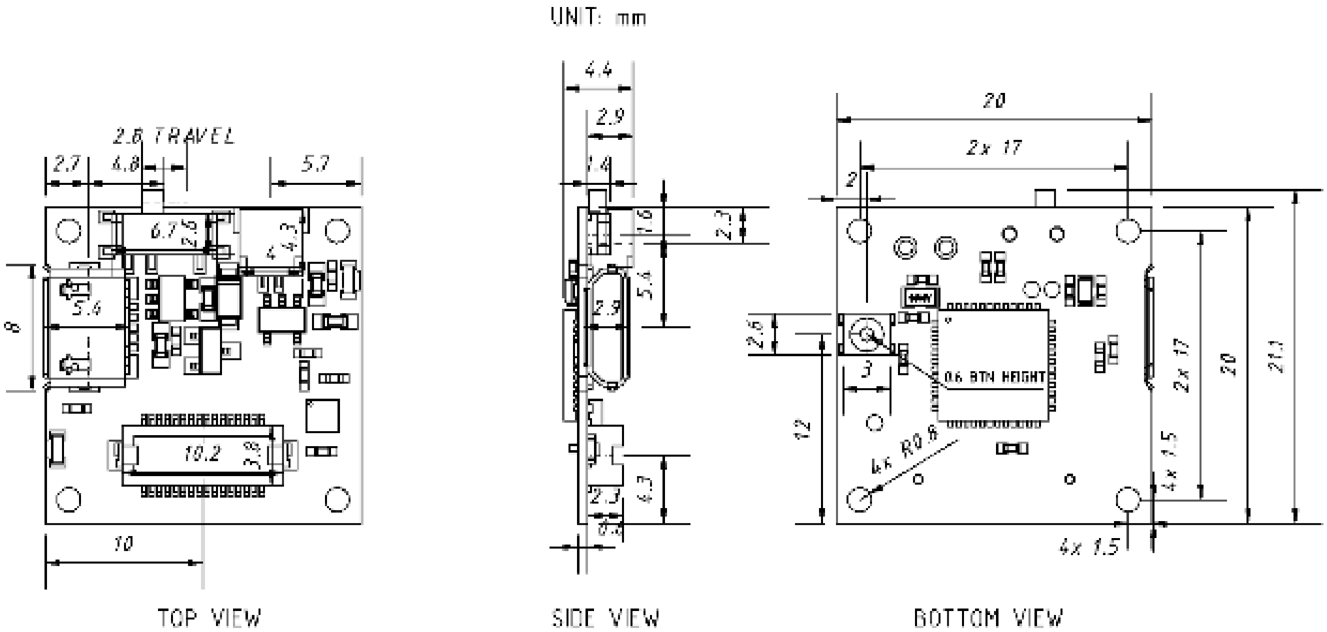


Figure 5 - **TinyDuino Bluetooth Shield**

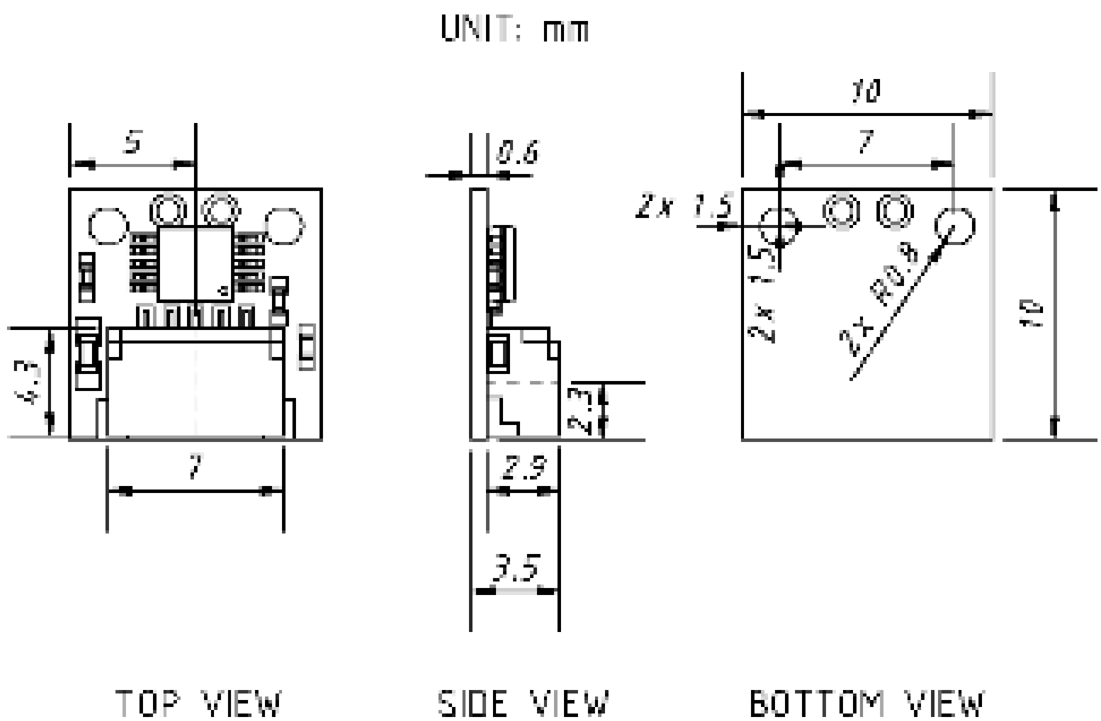


Figure 6 - **TinyDuino Proto-Board**

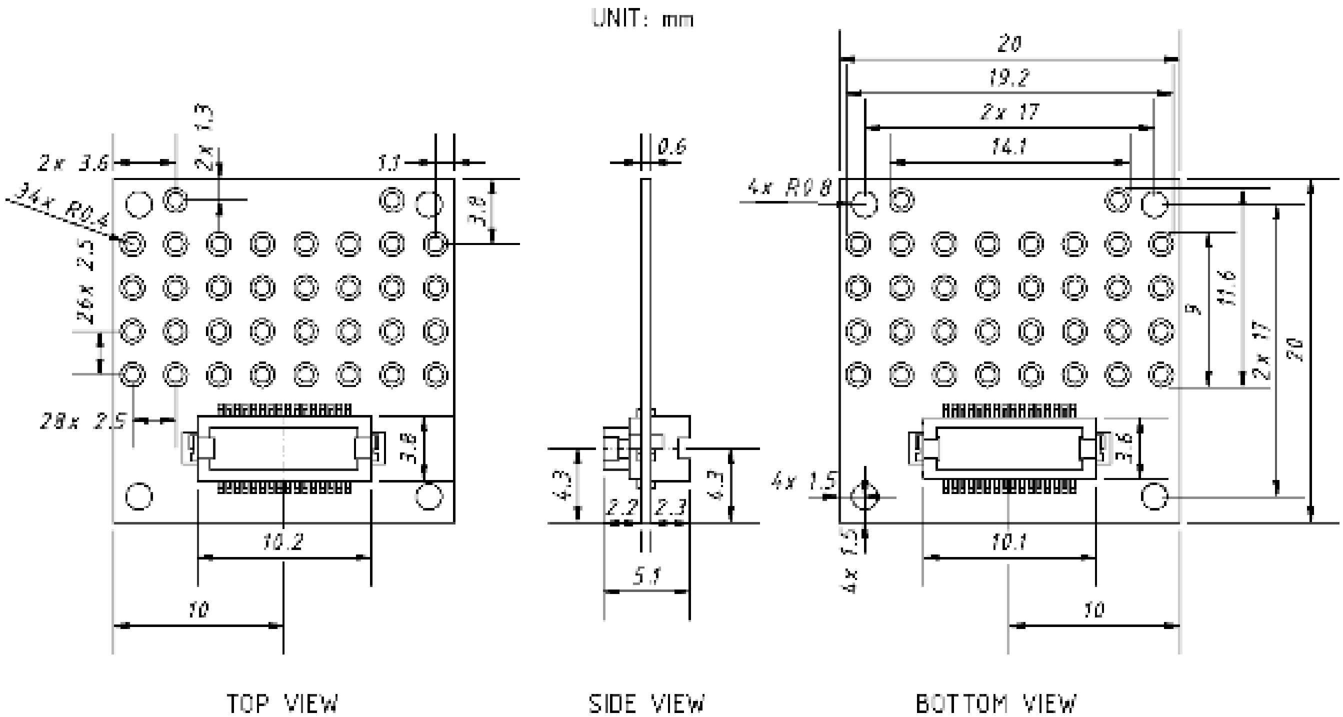


Figure 7 - **TinyDuino LED Integrated Board**

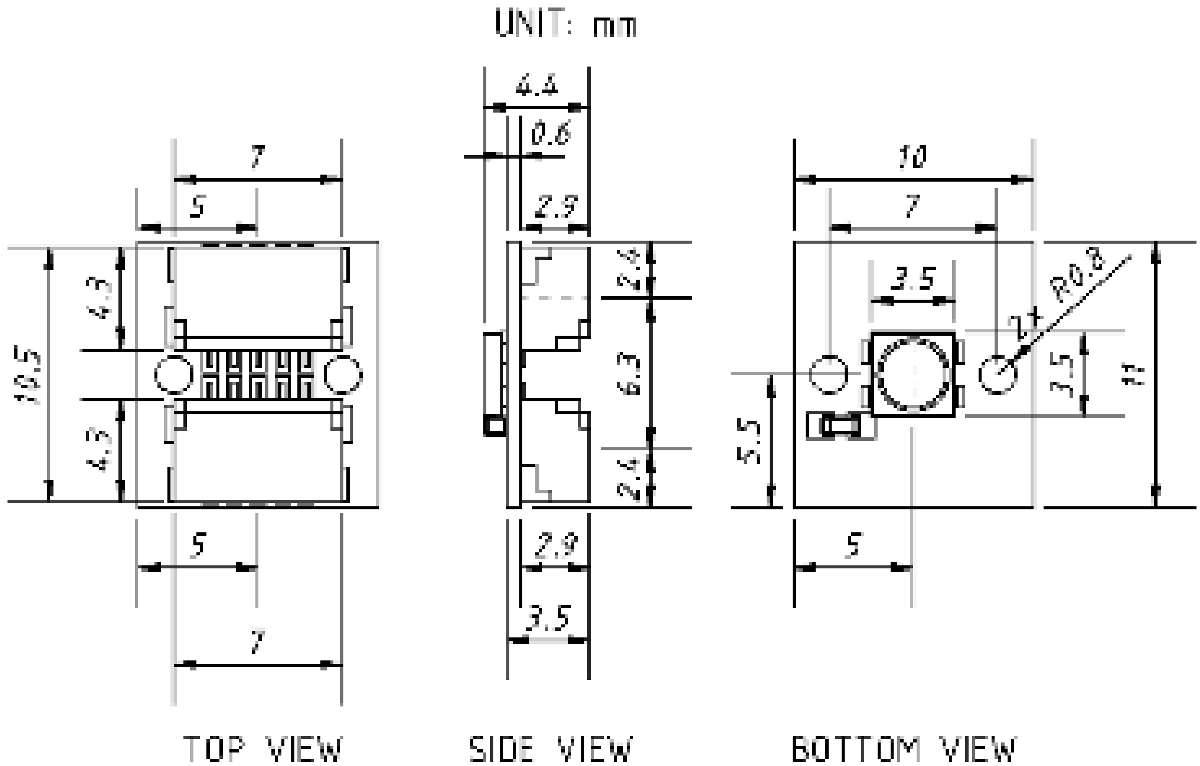


Figure 8 - **TinyDuino Buzzer Connection Board**

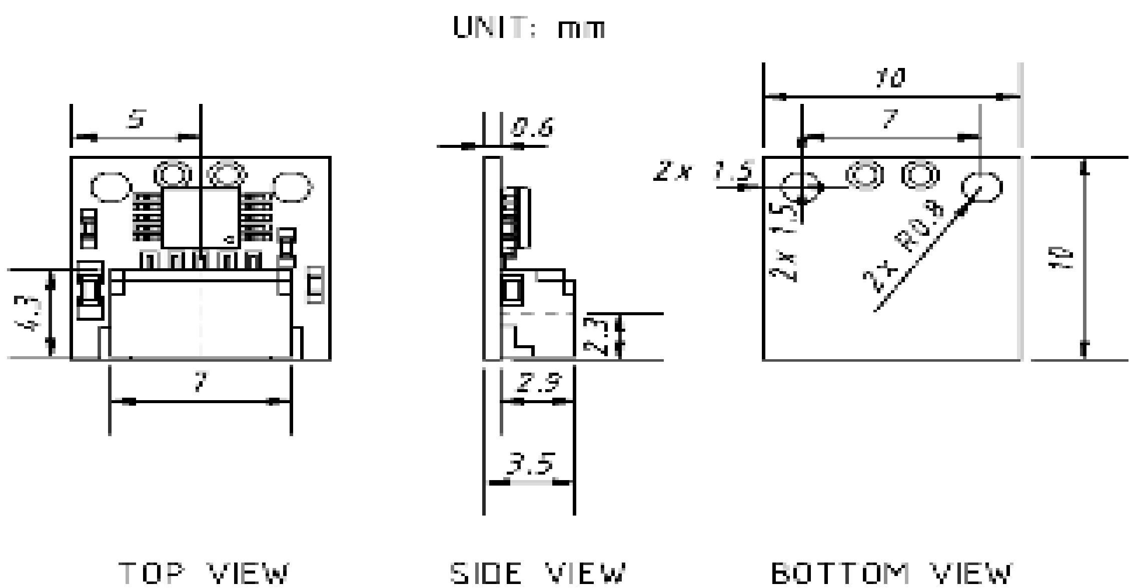


Figure 9 - **NavStrap Prototype 2D Export**

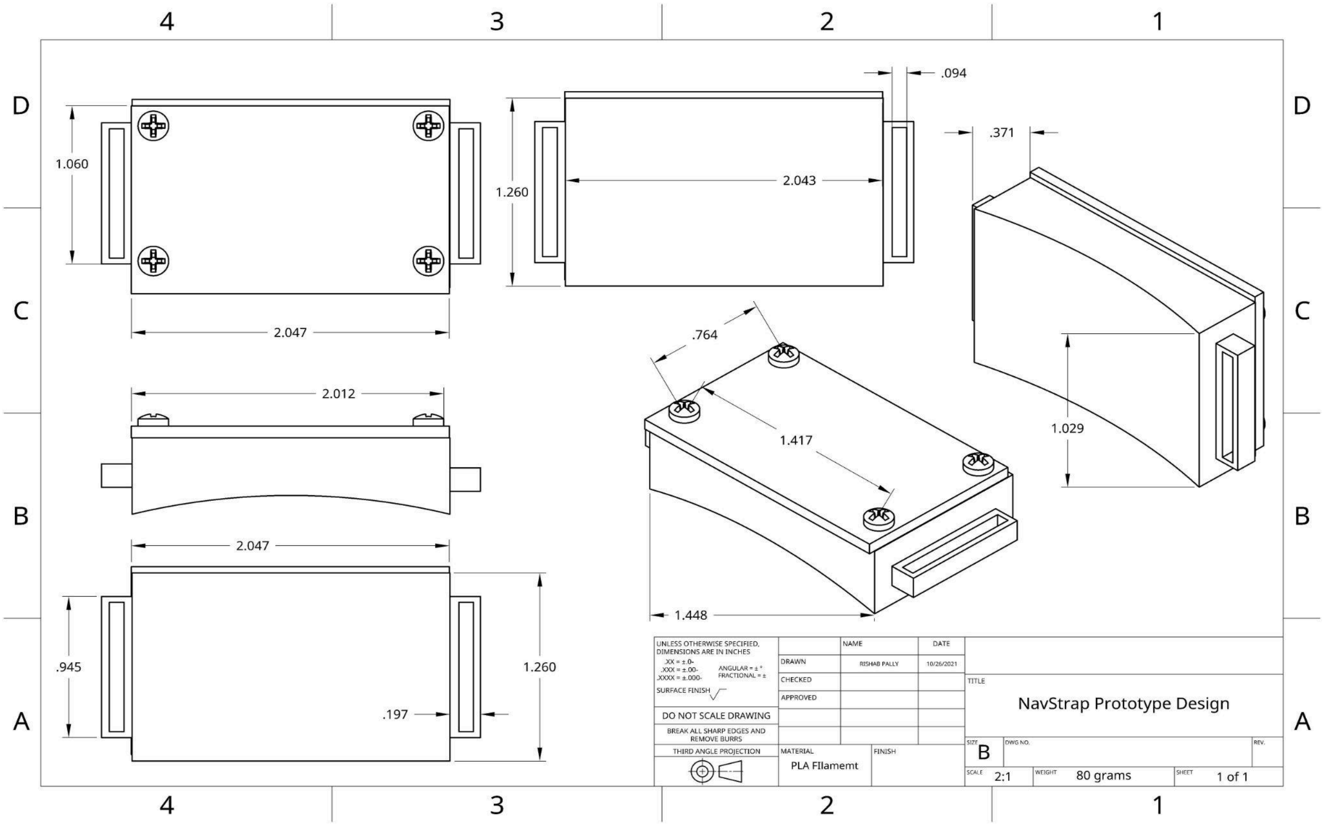


Figure 10 **- Expanded view of internal hardware components**

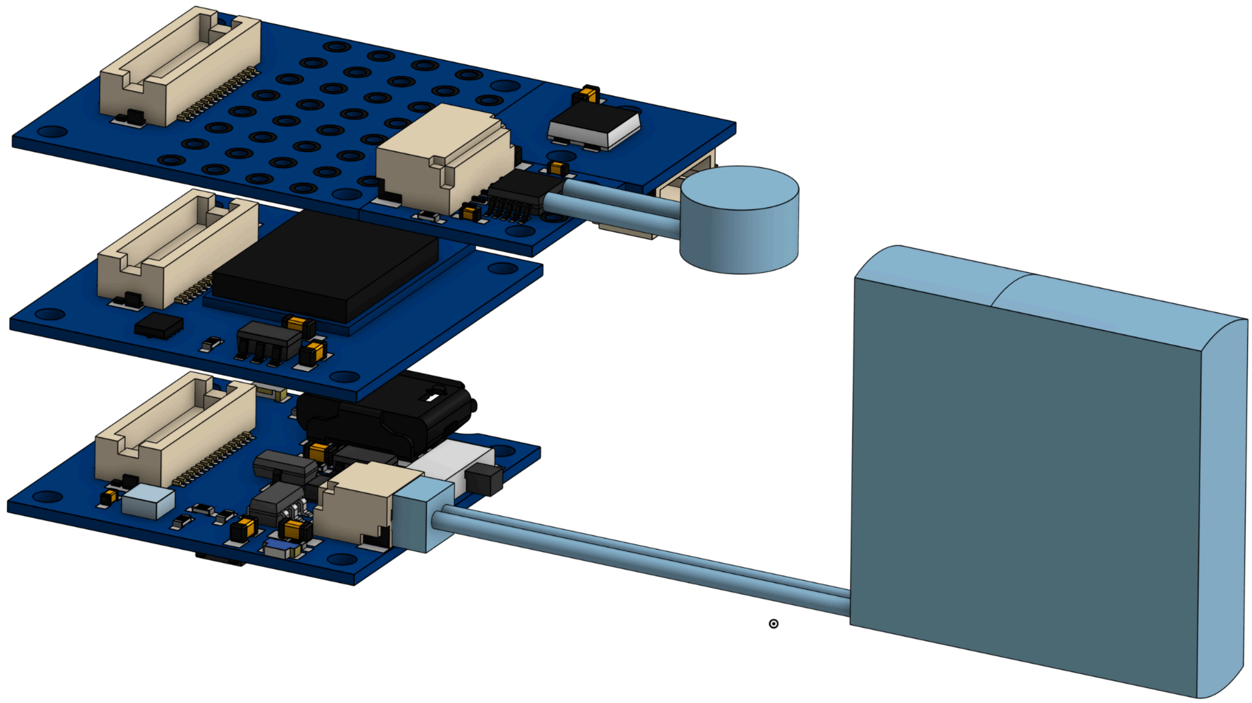


Figure 11 **- Housing with transparent lid**

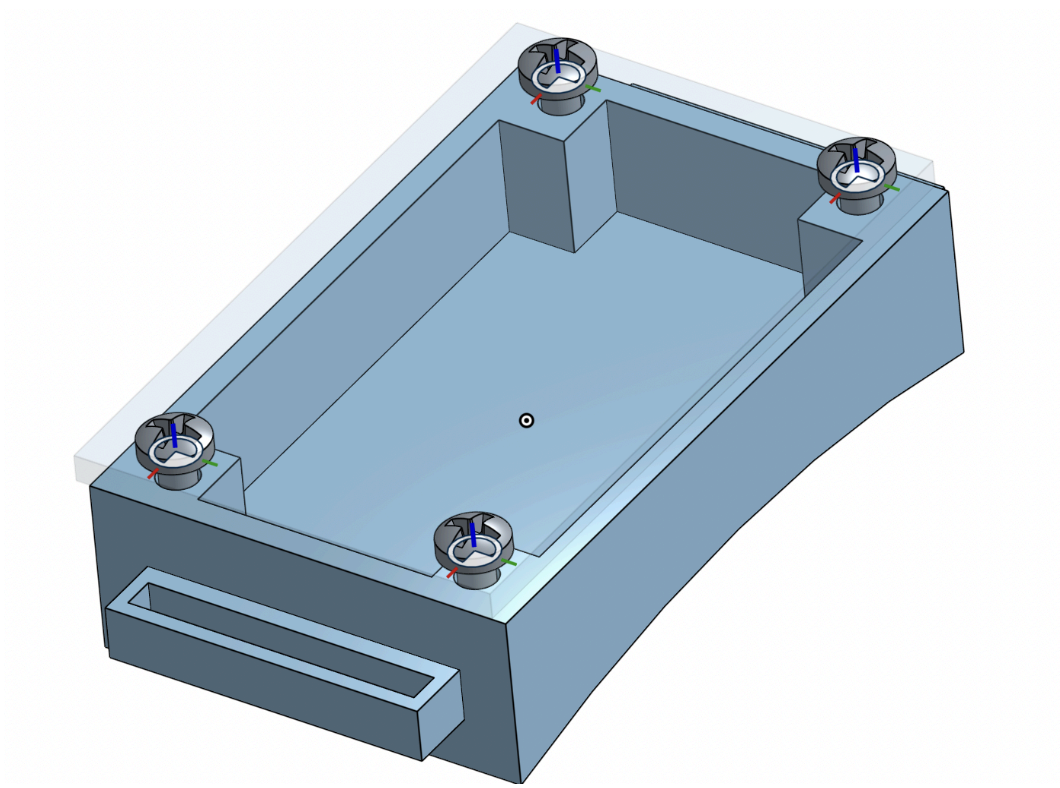


Figure 12 **- Expanded view with housing and circuits**

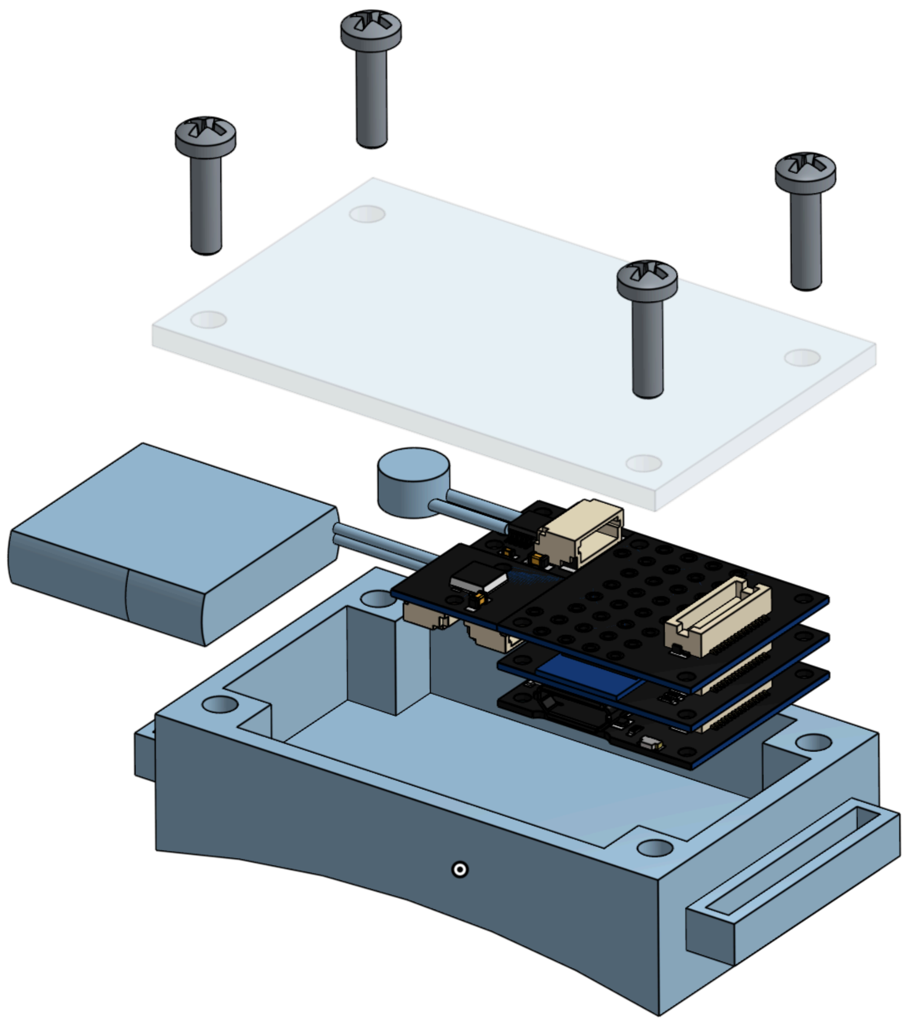
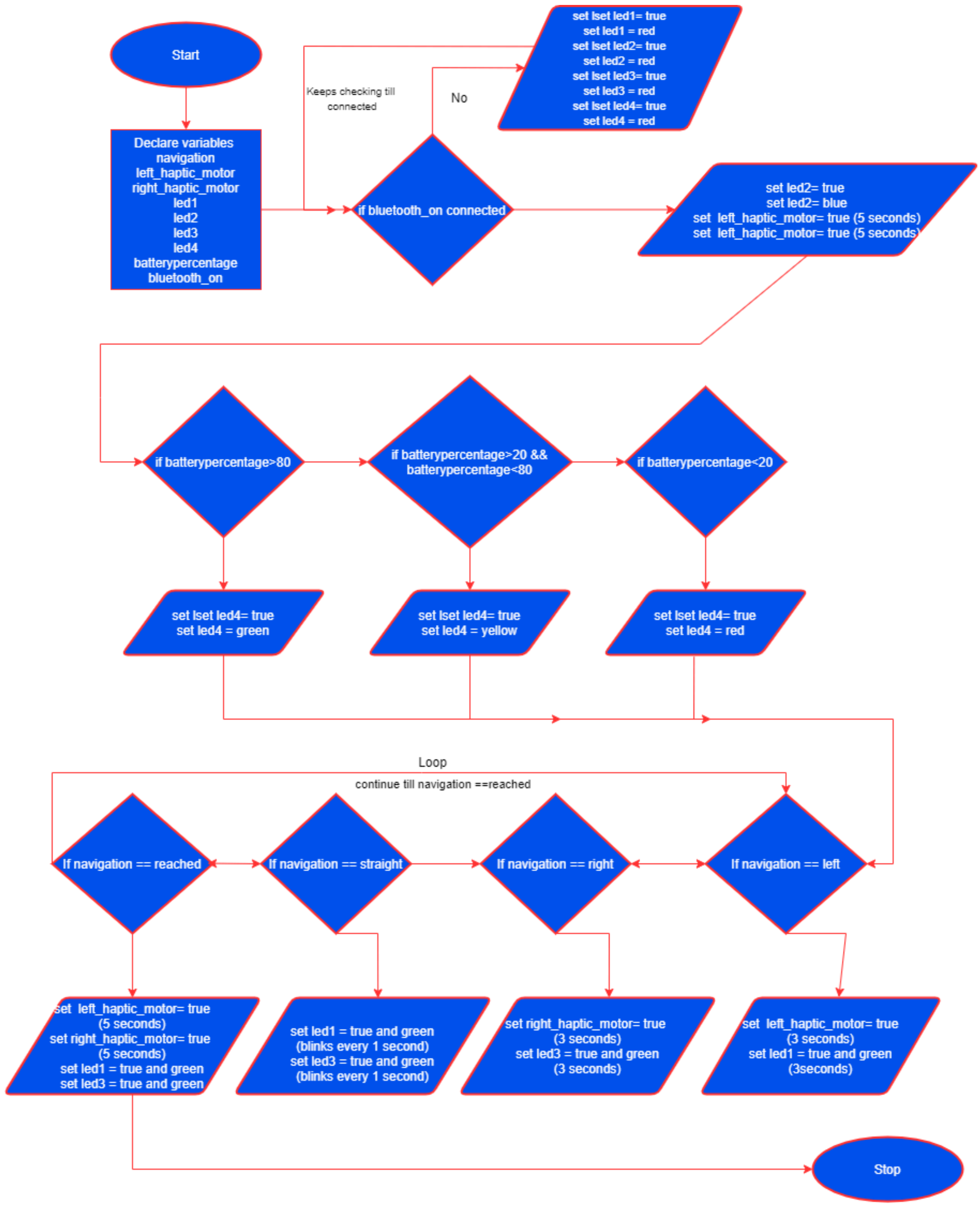


Figure 13 - **Programming Flowchart Diagram**



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.

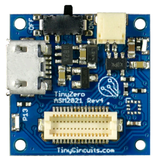
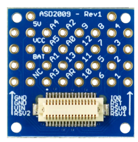
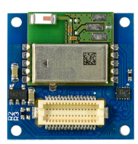
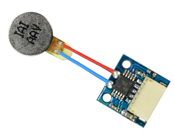
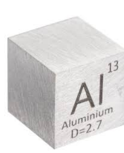
The second trial will utilize the navigation device's bluetooth connection, allowing the development team to direct the user manually through a new course. This trial further tests the navigation device's ability to overcome signal interference from obstacles, as well as test the limits of the bluetooth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

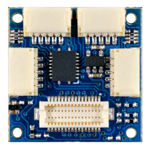
The third trial will utilize a smartphone placed on the user to transmit a premade script of navigation signals to traverse the user through a new course, independent of the development team's interaction with the user or navigation device. This trial is a practical test of the entire system to prove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

<u>Summary of Consultant Review - Jonah Spicher</u>

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.