

4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	<p>How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)</p> <p>Protects users against various extreme temperature conditions.</p>	<p>Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities</p> <p>Frostbite, hypothermia, heat exhaustion, etc.</p>
Global, cultural, and social	<p>How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.</p> <p>Development or operation of the solution directly coincides with the values, practices, and aims of the cultural groups it affects.</p>	<p>Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices</p> <p>Ability to spend more time with family, ability to be active outdoors, ability to have courage and freedom outdoors.</p>
Environmental	<p>What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.</p> <p>Radiation to the environment, increase in carbon footprint.</p>	<p>Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials</p> <p>Increase in radiation to the environment due to Bluetooth and RF frequency transmission. Increase in carbon footprint due to the addition in manufacturing of batteries.</p>

Economic	<p>What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.</p> <p>Minimal development cost, affordable final product for users.</p>	<p>Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization</p> <p>Our team's goal is to produce a final product that incorporates all desired functionality and usability constraints in as cost-effective manner as possible.</p>
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4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project

- If similar products exist in the market, describe what has already been done
- If you are following previous work, cite that and discuss the **advantages/shortcomings**
- Note that while you are not expected to “compete” with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

With cursory research, we were able to find some products such as the CORE Body Temperature Sensor (<https://corebodytemp.com/>) that are used to monitor core body temperature for athletics. This is similar to our product, but the key difference is that we are tracking temp at extremities rather than at the core. Temperature at extremities is often measured in a medical setting, but those settings rarely require battery power, radio communications, or a handheld application. Compared to the CORE Body Temperature Sensor, a pro of our design is that it is more robust. The biggest con is that our product is somewhat bulkier.

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
 - a. Instrumentation
 - i. The temperature sensors we will be using require knowledge of circuit design and how analog values can be used with I/O

- b. Microcontroller
 - i. We will be embedding a microcontroller. We will need to understand I/O, registers, high-level programming and analog to digital conversions to make this work
 - c. Wireless Communications
 - i. We will be using both RF and BLE for communication with our devices. An understanding of wave propagation, receivers and transmitters will be necessary.
 - d. App development
 - i. We will be developing an android app for this product. Software knowledge, in both front and back-end development, is necessary. along with an understanding of receiving and transmitting wireless data.
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.
 - a. Although the technology needed to complete this product is not revolutionary, the challenge lies in making a useful easy to use product that is:
 - i. Easy to wear
 - ii. Does not create abrasions for the user
 - iii. Accurately measures key locations on the body
 - iv. Cost efficient
 - v. Easy to use phone application for user interface
 - vi. Transfers data over long distances
 - vii. Works in extreme conditions

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

1. Decision to have an RF Gateway
 - a. This is important to the project's success because without having an RF Gateway, there is no way to get the desired range of 200 meters.
2. Decision to use Arduino MCU
 - a. This is an important design decision because the Arduino MCU is easy to understand, and members of the group have experience with Arduino Boards.
3. Decision to have an external case that houses the battery, MCU, and RF Modules
 - a. This is important to the success of the project because we could not find a good option to have the battery, MCU, and RF Module inside of a ski boot. These components are too large and would cause discomfort/pressure inside of the boot.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

1. Decision to utilize both BLE and RF Modules
 - a. Our team decided to utilize both BLE (Bluetooth Low Energy) and RF (Radio Frequency) Modules for data retrieval and transmission due to the various design constraints for our project which include a range of transmission, noise interference mitigation, and connectivity uptime.
 - b. Options our team considered during this design process include:
 - i. BLE
 1. Energy efficient, good local range, low interference, easy to connect
 - ii. Bluetooth
 1. Not as energy efficient compared to BLE, similar overall characteristics otherwise
 - iii. RF Modules
 1. Energy Efficient, multiple different options for modules, low cost, good range
 - iv. Wi-Fi
 1. Smartphone compatibility, secure
 - v. NFC
 1. Simple setup, low range, not compatible with all smartphones

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

Selection Criteria	Criterion Weight (%)	Apple	Android	Flip phone
Ability to Connect to hardware	30	6	8	0
User Interface Usability	25	8	7	1
Programmer Usability	30	5	8	1
Client Ability to Access	15	5	5	1
Total		6.05	7.30	0

We Chose to use a weighted decision matrix because it allows us to compare use multiple criteria to compare ideas objectively with numbers. Since we have a lot of things to consider when working with people and fragile technology, having the ability to rate all of the considerations in one place helps us to make decisions easily. The weighted decision matrix helps us to not forget about any important criteria and to take the emotion out of decisions.