# PTSD Detection Device

DESIGN DOCUMENT

Team #15
BAE Systems / America's VetDogs
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# Executive Summary

## Development Standards & Practices Used

- Agile scrum project management
- Gitflow version control on Gitlab
- Encapsulation/decoupling (define interfaces between components for clear-cut contract-based communications)

## Summary of Requirements

- Wearable device monitor's sensor data, and predicts the onset of PTSD episode symptoms.
- The wearable device notifies a service animal prior to the onset of PTSD episodes
- The wearable device is able to be powered on and off.
- The device is able to improve its ability to detect onset of PTSD episodes in advanced.
- The system (both devices) are durable, and able to last for an entire day.
- The system adheres ethical practices, and is not harmful for the user of the service animal.

## Applicable Courses from Iowa State University Curriculum

- CPR E 281: Digital Logic
- CPR E 288: Embedded Systems I: Introduction
- CPR E 381: Computer Organization and Assembly Level Programming
- CPR E 308: Operating Systems: Principles and Practice
- CPR E 488: Embedded Systems Design
- COM S 309: Software Development Practices
- COM S 252: Linux Operating System Essentials
- EE 321/422: Communication Systems I&II
- EE 201: Electric Circuits
- EE 230: Electronic Circuits and Systems
- SE 339: Software Architecture and Design

## New Skills/Knowledge acquired that was not taught in courses

- Circuit/Sensor design
- Android Development
- System Integration
- Communications Protocols [SPI, $I^2C$, MQTT, BLE, RF, ASK]

# Table of Contents

## List of figures/tables/symbols/definitions (This should be the similar to the project plan)

**Synchronous communication:** Synchronous communications over wires involves sending data over a bus accompanied by timing data.

**Asynchronous communication over a wire:** Asynchronous communication utilizes a specified flow-control method (usually something to mark message starts and ends). This communication usually communicates in the form of packets. Transmission is started and stopped, so there is not a continuous stream of data.

**SPI (Serial peripheral interface):** Mode of serial communication between devices over 2 synchronous data buses.

**$I^2C$:** Serial communication protocol where data is segmented into messages/frames of a specified size, while still using a clock signal to synchronize timing of messages between the 2 parties.

**Digital signal:** Signals represented using discrete values, usually low or high. Commonly used $I^2C$, SPI, and some other communication protocols.

**Analog Signal:** Signals which are interpreted by continuous values. Analog signals must always be converted to digital for software interpretation.

**Bluetooth LE:** "Bluetooth low Energy". A protocol for stream-based wireless communication between devices.

**SD card writing protocol:** Protocol for reliable data storage on SD cards. This is either a "native mode" with higher speed, or "SPI" mode, for communication over serial peripheral interface.

**ASK modulation (amplitude-shift keying):** A simple yet effective modulation technique commonly used for radio frequency identification. Some common uses include garage door openers and smart-home/IoT devices.

**SPO2:** Saturation of peripheral oxygen. Can be measured using the ratio of IR to red light reflected by skin. Provides an indication of user's respiratory system output.

**EDA:** Electrodermal activity: Variation of skin conductance in response to sweat secretion. Normally measured using electrodes. Indicator of intensity of emotional state, level of physical activity.

**PPG:** Photoplethysmogram: plethysmogram used to detect blood volume changes. Measured using reflection/transmission of light through dermis and subcutaneous skin tissue Provides indicators of cardiovascular output, heart rate, and blood pressure. These metrics have been proven correlated to stress, and environmental factors

**Accelerometer:** Device which measures linear acceleration. Useful as an indicator of the user's current state/environment. If a user is currently accelerating, or moving quickly, it is likely changes in their vitals are due to their environment and not PTSD.

**ECG:** Electrocardiograms measure small electric impulses sent through the body to cause heartbeats. The heart-beats affect cardiovascular output. These devices are not as feasible on wearable devices.

# 1 Team, Problem Statement, Requirements, and Engineering Standards

## 1.1 Team Members

| | |
|---|---|
| 1) Casey Halbmaier | **Software Engineer** |
| 2) Caden Backen | **Software Engineer** |
| 3) Coby Konkol | **Software Engineer** |
| 4) Ben Gardner | **Electrical Engineer** |
| 5) Andres Ceballos | **Electrical Engineer** |
| 6) Nihaal Koyakunju Zaheer | **Computer Engineer** |

## 1.2 Required Skill Sets for Your Project

Schematic design.
Soldering.
Embedded system design/programming.
Mobile app development.
AI/Algorithms design and development.

## 1.3 Skill Sets covered by the Team

**Casey**: Experience in Java, C, and JavaScript programming languages. Organized and cooperative in a team.

**Caden**: Experience with Python, C, Java, Matlab, Simulink. Job experience with large scale machinery, specifically embedded systems.

**Coby**: Good with Linux, containers, cloud infrastructure, DevOps, APIs, backend, data/pipelines. Most comfortable with Java, Python, C, Bash scripting. History of making apps.

**Ben**: Experience writing C for embedded systems and schematic drawing. Worked on a professional development team.

**Andres**: Autodesk inventor, CAD, Quartus Prime, Creo Draft, Circuit Design, and beginner level in C.

**Nihaal**: Prior experience with debugging and writing code for hardware. Good with Linux, Containers, Docker, Bash, C, Python.

## 1.4 Project Management Style Adopted by the team

Scrum/Waterfall Hybrid

## 1.5 Initial Project Management Roles

**Project Manager:** Casey Halbmaier

Drive the team towards productivity. Hold team members accountable for commitments, and orchestrate internal/external communication.

**Scrum Master:** Ben Gardner

**Technical Lead:** Coby Konkol

Drive integration of the technical various team members. Ensure team-wide synchronization for technical tasks, help in any role that is falling behind.

**Software Design:** Caden Backen

Responsible for the patterns, architecture, and implementation of software, both for the algorithm (for early PTSD detection) and in the hardware.

**Hardware Design:** Ben Gardner and Andres Ceballos

Design and implement physical design. Work with any sensors, wires, ICs, or any other hardware requirements for the wearable device and feedback device.

**Interfacing Team Lead:** Nihaal Zaheer

Establish communications between the sensors (SPI, I^2C, GPIO, MQTT …), microcontroller, dog vest device, and phone.

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## 1.6 Problem Statement

If a discrete and wearable device existed that is capable of detecting PTSD episodes, support for veterans with PTSD would become much cheaper, accessible, and faster than it currently is. Veterans could either wear the device and respond accordingly, or the device could notify a service animal, then the animal would respond. These devices could also prove to be a good tool for trainers to train service animals.

American VetDogs proposed a potential solution to this problem. We are challenged with designing and building a prototype for a device that monitors the veteran's physiological data, detects PTSD symptoms in advance, and alerts a service animal that an episode is imminent.

## 1.7 Requirements & Constraints

Functional requirements:

- Reliably monitors the user's physiological data.
- Accelerometer provides information about the user's movement.
- Detects any abnormal behavior (spikes) in blood pressure/heart rate consistent with a PTSD episode.

A project funded by Texas A&M University used cardiovascular and acceleration data from commercially available smartwatches to identify onset of PTSD episode symptoms using machine learning. They identified episodes with (83% accuracy and 0.70 AUC). As such, we should attempt to provide detection with similar accuracy. Our goal is **80% accuracy and 0.65 AUC**.

- Communicate with the device on the service animal that a PTSD episode is imminent.
- The user should be able to dismiss the device before the dog is notified
- The device on the service dog should alert the them that a PTSD episode is imminent
- The user should be able to power off and on the device.

Qualitative aesthetics:

- Must be discrete. It was emphasized in the project proposal that the device should not disturb anybody in the vicinity.
- Dog notification is quiet (or at least subtle/non-disruptive) **(constraint)**
- The device worn by the user should be comfortable and non-invasive

Economic/market requirements:

- We are given a budget of $5000 for designing a prototype **(constraint)**
- The end product should have a lower cost than smart watches and other biological monitoring devices on the market. Our end-users are commonly disabled and may have a fixed income. This may limit their ability to purchase expensive products. Cheaper manufacturing techniques will be a consideration after our initial design.

UI requirements:

- The interface with the user should be accessible for various disabilities. We must take into account motor function, vision, hearing, and any other disabilities we discover common among our primary users, veterans.
- The interface should be simple to use so notifications can be easily dismissed before alerting the service animal. Our primary clients are also commonly members of an older generation, commonly less skilled at using technology.

## Performance requirements:

**Algorithm performance:** The PTSD detection device should be more tolerant of false positives than true negatives (we would rather have the device alert the service animal when there is no PTSD symptoms than not provide a notification when there is an episode). The receiving operating characteristic (ROC) graph for classification algorithms. This graph provides intuition about how a classification algorithm performs. A higher value means a higher portion of the output is correct. We can also look at the False positive rate, and true negative rate (portion of episodes missed).

- The device must have a minimal number of missed PTSD episodes. Upon further study, we should determine a goal metric for this requirement. This means we have low tolerance for the true negative rate. We should shoot for a rate of under 0.2 (20%).
- We should have a reasonably low number of false-positive notifications for the dog. The dog being alerted that they need to respond is a low-damage situation, while the dog not being alerted during a PTSD episode is potentially embarrassing to the veteran, and disruptive to the situation. This can be measured with the false-positive rate.

**Combined algorithm performance:**:
These first two performance requirements can be quantified using the area under the curve (AUC) of the receiving operating characteristic (ROC) graph. An AUC value of over 0.65 would assert that most of the positive outputs are correct.
**Durability:** The device should be durable since it is intended to be worn everywhere the user goes.

- Should be drop/impact resistant
- Should be water-resistant
- The battery/device for the monitoring device should last at least 24 hours.

## Legal and Ethical requirements:

- We are storing, processing, and moving medical vitals from our clients. In order to allow this prototype to be on the market, we would need to follow local laws for computer-based records. These laws vary by state and country. This legal consideration of medical information is outside the scope of our prototype, and we will **not** be putting significant efforts into following these standards and requirements.
- The materials used in the feedback device and the device worn by the user should be made of materials with no potential to harm the users.
- The feedback device should use an ethical mode of communication for notifying the service animal

## Maintainability requirements:

- We want the devices to be modular, so each component can be easily updated and replaced

- Backward compatible, so updating different components doesn't require a replacement of the entire system.

Security Requirements:

- End-to-end encryption of vitals
- In-place encryption of stored vitals and information (Not necessary for prototype).
- Authentication/identity verification for accessing information
    - (Not necessary for the prototype.)

Testing requirements:

- The system should have a minimal false positivity rate.
- The device should be tested with our partner company, VetDogs, to ensure the subtleness of the alerts and the comfortability of the devices on both the user and the dog.

## 1.8 Engineering Standards

- IEEE 802.15.1: WPAN / Bluetooth - We plan on using Bluetooth to connect separate devices (phone and wearable) in our design.
- IEEE 802.11: WiFi - Future iterations may use WiFi.
- ISO/IEEE 11073: Medical / Health Device Communication Standards - We will be designing/using a wearable device that collects health data and communicates it to another device.
- IEEE 360-2022: IEEE Standard for Wearable Consumer Electronic Devices - We are planning on designing a wearable device to collect heart rate/blood pressure.
- IEEE 370-2020: IEEE Standard for Electrical Characterization of Printed Circuit Board and Related Interconnects at Frequencies up to 50 GHz - We will be doing some PCB design and testing
- Revised 508 Standards and 255 Guidelines https://www.access-board.gov/ict/ - accessibility standards are used on government and official user interfaces to ensure access for people with physical, sensory, or cognitive disabilities. Section 255 covers telecommunications and customer-premises equipment While 508 covers information and communication technology.
- Web Content Accessibility Guidelines https://www.w3.org/WAI/standards-guidelines/wcag/ WCAG documents explain how to make web content accessible to people with disabilities. If we are designing any interfaces on screens, this standard can ensure usability for our clients.

## 1.9 Intended Users and Uses

Use cases:

- Veterans and non-veterans with a history of PTSD episodes need to be able to prevent these episodes before they happen. (Currently, veterans are the main testing group for this project.)
- Service dog trainers need to be able to determine when a PTSD episode is happening so they can train service animals more effectively.

Who benefits from the project:

People with PTSD episodes benefit from the prevention of PTSD episodes before they happen, reducing their stress and pain and thus improving their quality of life.

The families of people with PTSD indirectly benefit from the improvement of their family member's quality of life. Seeing a loved one routinely suffer and relive unimaginable trauma significantly affects the psyche of everyone witnessing the episode.

Service dogs of people with PTSD episodes benefit from the alert of a PTSD episode, which makes it easier for them to know when they need to assist their owner.

# 2 Project Plan

## 2.1 Task Decomposition

Here is our task decomposition chart. It is split in figures 2.1.1 through 2.1.4 because it was too wide to be readable in a document.

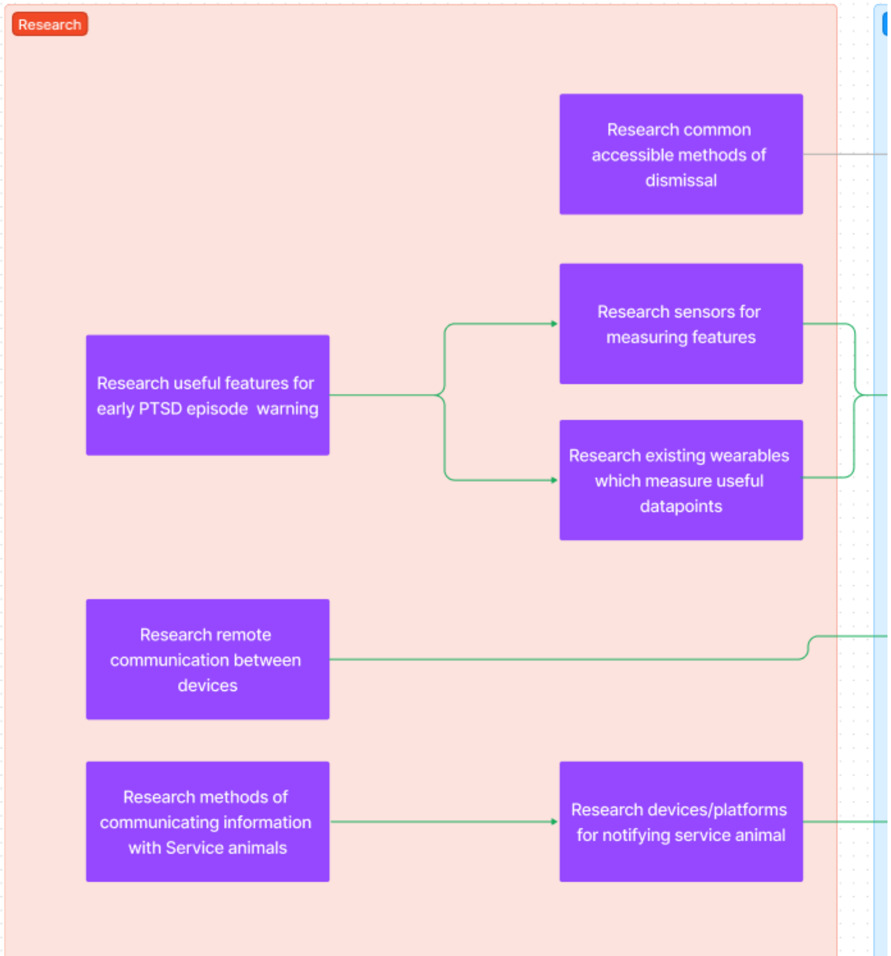

Figure 2.1.1: Research tasks

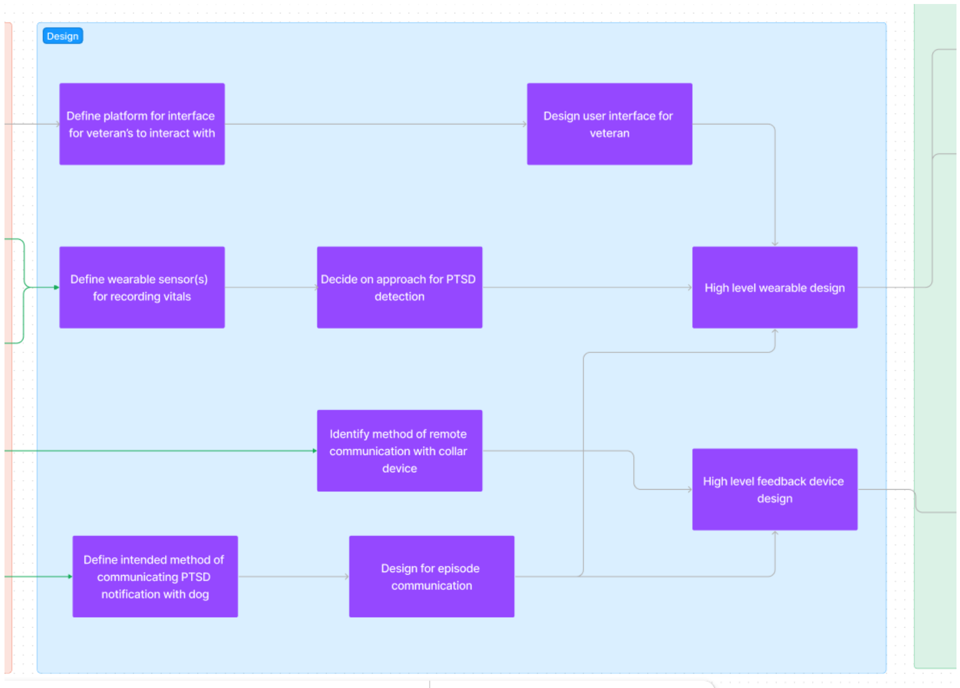


Figure 2.1.2: Design Tasks

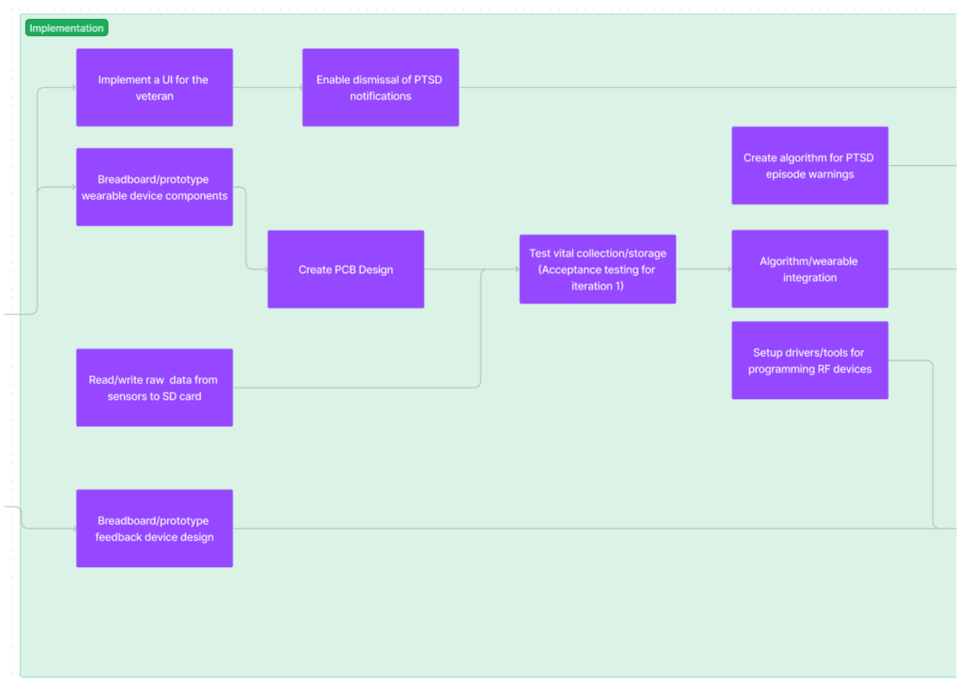


Figure 2.1.3: First half of implementation tasks

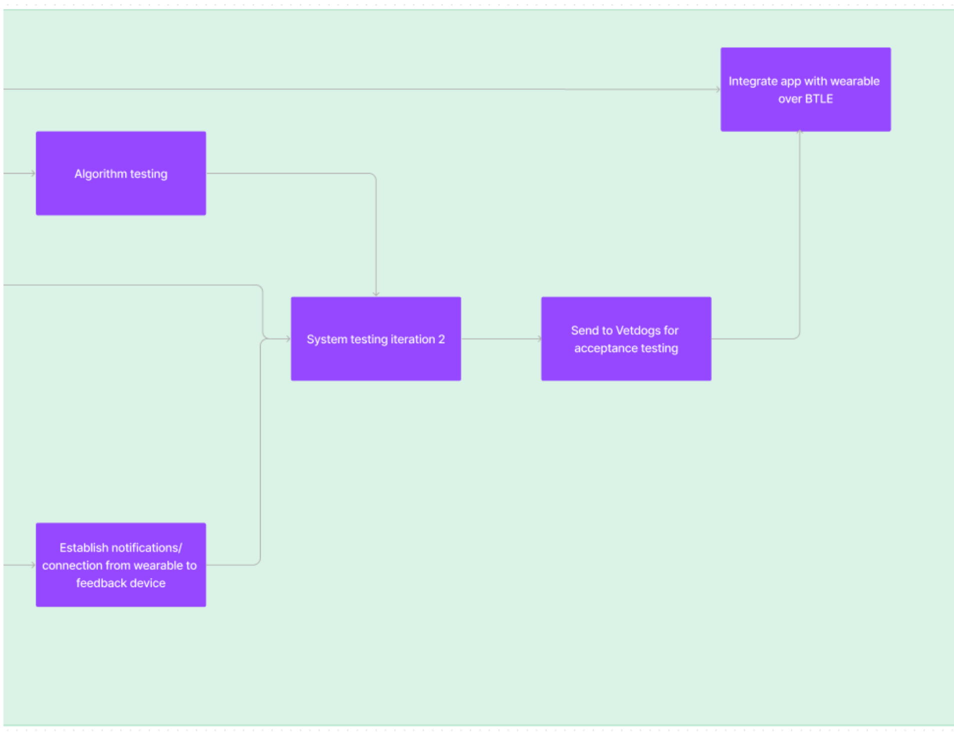


Figure 2.1.4: Second half of implementation tasks

## 2.2 Project Management/Tracking Procedures

We will be utilizing a waterfall/agile hybrid. Pure agile doesn't make sense due to the relatively low amount of person-days of work there are and the infeasibility of meeting as often as pure agile calls for. Also, most tasks should be independent enough that a task or group of tasks can be assigned to someone, and they can complete it on their own without checking in until the end. On the spectrum of waterfall to agile, we aim to be closer to agile.

We will use a GitLab board to track progress throughout the project's duration. Milestones are defined as established in the task decomposition.

## 2.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

**Milestones**

(10/31/2023) - Research Phase Complete

(11/20/2023) - Spotlight Research Deadline

(12/10/2023) - Design Phase Complete

(01/20/2024) - Initial Redesigns Deadline

(04/28/2024) - Implementation Phase Complete

(05/01/2023) - Final Project Complete Deadline

**Metrics/Evaluation Criteria**

- For the research phases, each task is considered 'Complete' when our design can be fully realized based on what we've found from research. A general rule of thumb is to answer all questions related to our research's guiding question.
- For the design phases, each task is considered 'Complete' when the design can be fully realized as a working prototype.
- For the implementation phase, each task is considered 'Complete' when our implemented prototype works to the specifications we laid out in our design phase.

## 2.4 Project Timeline/Schedule

Figure 2.4.1 shows a Gantt chart of our expected schedule.

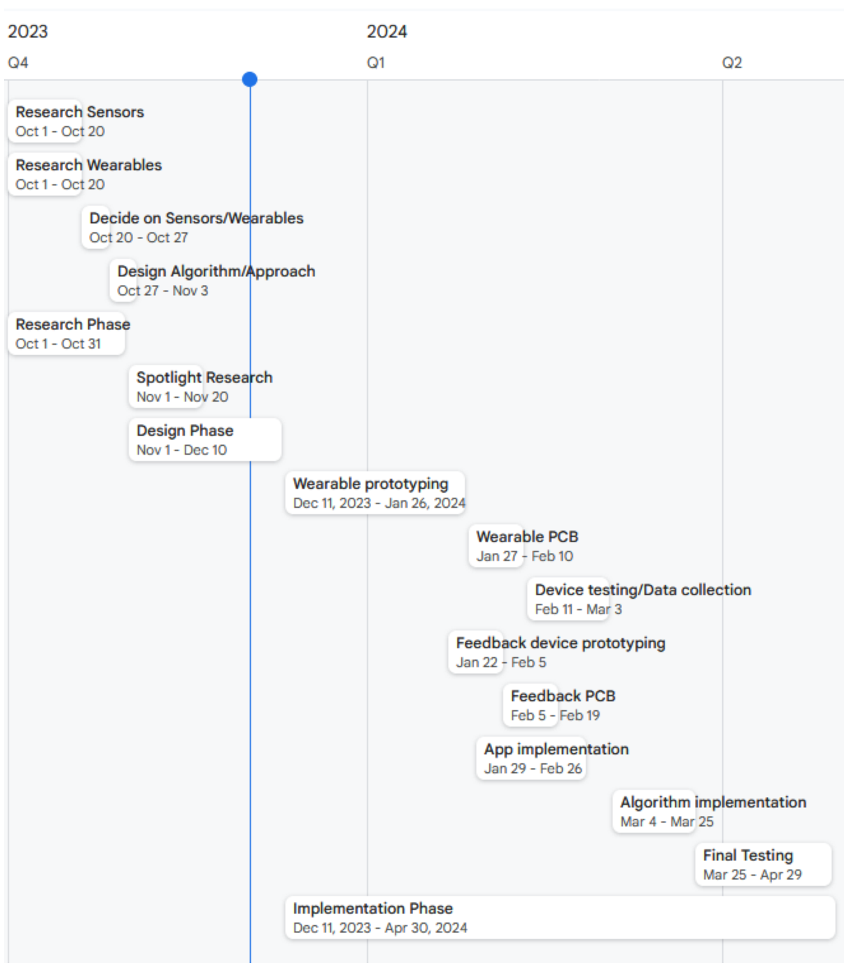


Figure 2.4.1: Project Gantt Chart

## 2.5 Risks And Risk Management/Mitigation

One such tool or hardware that would pose a risk factor in our project would be the integration of the blood pressure sensors. Based on our research and findings, we have found out that the commercially available blood pressure sensors uses inflatable cuffs, which are not comfortable to wear for prolonged periods of time. Additionally, to measure the blood pressure, the user needs to keep their arm stationary. Since this is a wearable device that the user would have on at all times, the blood pressure readings wouldn't be accurate.

An alternative to using a cuff-based blood pressure sensor is to use a Photoplethysmogram (PPG) device. PPG is a measurement of how light is reflected by the skin. As veins/arteries expand and contract with heartbeats, the volume of blood under the skin changes in unison. This causes the skin to reflect different amounts of light. Using PPG we can easily estimate blood pressure, measure heart rate, and even predict oxygen saturation, non-invasively.

A big risk for wearable devices for collecting physiological data is security. The identities of the users cannot be associated with the device (since their association infers that they have PTSD). The data on the wearable device could be used to extract information about their medical conditions. This is private information and should be thoroughly protected.

In practice or any commercial release of this device, all data should be encrypted both in place and in transit. Users should be thoroughly authenticated for accessing any data associated with them. However, with the workload of designing and building the wearable and feedback device, as well as implementing an algorithm for early detection, it would not be possible for our group to implement sufficient security, safety, and encryption protocols to meet this requirement.

## 2.6 Personnel Effort Requirements

Table 2.6.1: Personnel Effort Requirements

| Task | Estimated Number of hours |
|---|---|
| Research for early PTSD warning | 20 |
| R&D on vital sensors | 30 |
| Research on existing wearables | 15 |
| Research on Methods for communicating with service dogs | 20 |
| R&D of cross product Communication | 60 |
| Integration of sensors with Prototype device | 40 |
| R&D for Service Dog notification device | 40 |
| Integration of all devices | 80 |

| Task | Estimated Number of hours |
|---|---|
| Research for early PTSD warning | 20 |
| R&D on vital sensors | 30 |
| Research on existing wearables | 15 |
| Testing | 100 |

## 2.7 Other Resource Requirements

Information Requirements

- **Connections to the VetDogs of America veterans group:**

This project requires our group to create a device worn by veterans and people who suffer from PTSD-induced episodes. As such, it is important to be able to communicate and ask questions to veterans who can provide valuable feedback in both our research of PTSD and our designs of our wearable device.

- **Connections to Service Dog Trainers:**

In order to ensure that our PTSD Detection Device works, we need to have connections to service dog trainers to test that the device accurately alerts the service dog. These connections will also help our team to design the device to accurately fit a service dog.

- **Access to Iowa State University Studies on PTSD:**

Having access to scientific studies on PTSD that are archived in Iowa State University's library will be necessary to get accurate data on the effects of PTSD and how PTSD episodes occur.

- **Access to biometric data from previous studies:**

Having access to scientific studies on PTSD and the biometric data provided will be necessary in order to create an accurate algorithm for our wearable device. The team has reached out to multiple sources to gain access to their studies and are currently awaiting a response.

## 4.1 Design Content

The initial design comprises three components: a wearable device, an interface for user interaction, and a feedback device that receives a signal and notifies the dog to take action. The combination of these components detects PTSD hyperarousal episodes and notifies the service animal of the episode. It is also within the scope of the project for the veteran to turn the device off and on.

## 4.2 Design Complexity

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles.

2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

The wearable device needs to consist of sensors collecting biological data, processing and analyzing the data, and then responding accordingly based on the given information. There are not many existing research studies on the early prediction of these episodes, and non-invasive, continuous monitoring of the vitals of ambulatory (active, self-moving) individuals has already proven to be a challenge for the medical industry, with a limited number of accurate, reliable devices within a reasonable cost.

The wearable device also needs to be able to be updated with a new and improved algorithm for detection as well as remotely send discrete commands to a service animal. The wearable device should also have a long-lasting battery since it will be worn all day and is critical to obtaining vitals critical to the system's functionality.

The feedback device should be discrete, and be able to subtly receive messages and interact with a service animal. Additionally, the feedback device should have a long-lasting battery life since it is designed for everyday usage, and it is crucial to the success of the design.

Considering two modes of user interaction with varying capabilities and at least one form of wireless communication, we will need to address wireless communication, compression/serialization of data, and effectively design an IoT distributed system with at least two nodes.

### 4.3 Modern Engineering Tools

For asynchronous collaboration with the team, we utilized Figma as a tool for diagramming and traditionally visual activities, Gitlab for task management, and Google Drive for file/artifact organization.

In order to conduct focused, thorough preparation for the project, we used several activities commonly used as tools to produce effective collaboration and idea generation among engineers.

As an approach for user-specific and problem-specific research, we used journalistic mapping to brainstorm the problem, identify the context for its usage, and properly frame our user research, market research, and other research to be done.

After conducting research, we performed user-story mapping (commonly done in Agile Scrum teams to define clear use cases and purpose for tasks) to generate user-focused problem statements. This enabled us to identify tasks our system should perform, specific to our target users, and the desired outcome/benefit that arises from that statement. The result of this tool is a clear definition of the tasks and main facets of the engineering problem we aim to solve.

Following the problem redefinition, we are iteratively creating designs for the various components. Figma is to be used primarily for UML, context, and other high-level designs.

For hardware design we will use  Altium for designing PCBs.

In our software design, we will utilize Gitflow, with the provided Gitlab as a version control platform. Additionally, we will use GCC as a C compiler (needed for embedded software design) if needed, ISU provides servers for any backend software that we need (none are present in our current design), and the developer's choice for which IDE we will use. Our platform/tool of choice for any mobile software is not defined yet. Any other languages, frameworks, or tools we need to use will be decided on later.

### 4.4 Design Context

Table 4.4.1: Design Context

| **Area** | **Description** |
|---|---|
| Public health, safety, and welfare | The wearable cannot be harmful to the user.<br>The dog's wearable device should not be disruptive to the dog or anybody in its proximity.<br>The veteran's quality of life would be drastically improved if PTSD episodes can be preemptively handled. |
| Global, cultural, and social | We have chosen to use a vibration motor to signal the dog as opposed to something like a shock or a noise, as those are not considered very ethical options in our culture and the culture that will use it.<br>Our device, upon success, will add to the modern research and development in utilizing wearable devices for continuous improvement of users' daily lives by aiding in the prevention of potentially harmful/painful situations and uplifting members of the community in need of assistance for improving their daily quality of life. |
| Environmental | The wearable device will likely be 3D printed using plastic once we move further in our prototyping. Plastic is generally not a very sustainable resource, so we aim to use recycled or other more sustainable 3D printing filament options. |
| Economic | Our product should be relatively affordable. We plan to use relatively cheap sensors and other components. It needs to be affordable because our main audience, veterans, generally are not very wealthy and the device is meeting a medical need. Also, a charity may be funding these devices for some people, so we would like to not put undue financial strain on them. |

### 4.5 Prior Work/Solutions

There is no wearable technology commercially available on the market today for PTSD event detection. However, there have been recent efforts to design such a device. In 2022, a project funded by Texas A&M University developed a method of detecting PTSD hyperarousal episodes using heart rate and body acceleration. They tested 4 separate machine learning algorithms and found that using the XGBoost optimized gradient descent optimizer algorithm, they were able to predict PTSD episodes with over 83% accuracy and an AUC (area under the ROC curve) of 0.7%. Their algorithm had several key constraints that our group was not faced with. First, they limited their design to currently off-the-shelf commercially available devices to maximize the potential user group's size. As a result of this limitation, they were constrained to utilize only basic heart-rate sensors and body acceleration, the second major limitation that we are not constrained by.

A separate senior design group from  2022-2023 had this project proposed by BAE and attempted to use a smartwatch, cross-platform Flutter app, and custom dog collar device. We talked to some of the group members on the project. In this conversation, we asked about what vitals they used, what challenges they encountered in their work on the project, what some of their design/platform decisions were, and several other questions. Apple devices are not compatible with many Bluetooth devices, commercially available heart-rate sensors have very high-level APIs limiting access to more raw data, and continuously measuring blood pressure in a non-invasive way, especially with mobile individuals, is a challenge fresh to the medical research community. This information will significantly impact our platform decisions and sensor decisions.

### 4.6 Design Decisions

We currently do not have data available to create an algorithm for detection, and that may become available as we continue to research and build a relationship with our client. We are approaching this problem in several ways.

We decided that our best course of action would be to focus on making a minimal viable product (MVP) for the hardware functional as soon as possible.

In addition to building a simple first iteration of the hardware for quick feedback, we reached out to 2 separate entities (the DOE lab at ISU, and researchers in the project funded by Texas A&M) requesting access to their data for review.

We determined that WiFi would not be a great avenue to support the communication of data between our devices, and we would prefer to use radio communication with ASK (Amplitude-shift keying) modulation for communications between the wearable and the feedback device because it is a common and well documented way to send “ping” signals from one device to another. This protocol is used in many applications including garage door openers, and home automation systems. For communication between the wearable device and a user’s mobile device, we plan to use Bluetooth LE as it is widely supported and relatively simple to implement.

We also decided that the main computation power needs to happen on the user’s wearable device and should not rely on the user’s phone device. This will limit the potential communication errors and potential reliabilities. In addition, this will make the device more discrete.

### 4.7 Proposed Design

As a group we have been able to determine the core parts of our design that include a wearable device by the user, a device attached to the service animal, and a phone to sync data from the wearable device.

We have purchased parts for assembling a simple PPG device, as well as an evaluation kit for the MAX86150 (an integrated PPG, SPO2 sensor). This device showed a pattern of similarity between the ECG output, and PPG raw sensor values (integrated red and IR output from a photo-diode).

### 4.7.1 Design 0 (Initial Design)

Design Visual and Description

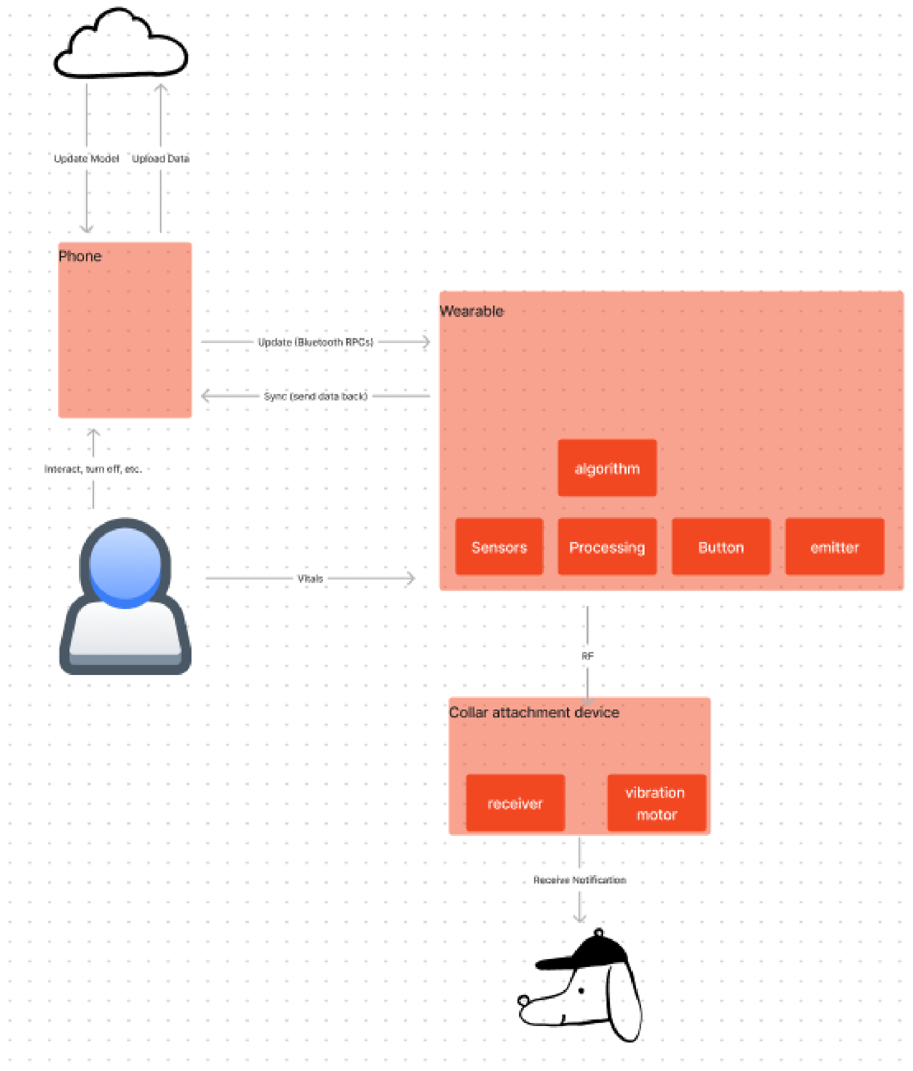


Figure 4.7.1.1: Design 0 Diagram

**The Feedback Device**

The feedback device receives a signal to tell the dog to go to the veteran. The dog is trained to go to the veteran and notify them of their potential oncoming episode. This device functions similarly to a pager and will buzz whenever signaled by our user's wearable.

**The Wearable Device**

The wearable device has the core functionality. Sensors record vitals, and it processes the signals to be useful. The algorithm is located in the wearable for early PTSD detection. A button is located for control of the wearable device, an emitter sends signals to the dog device upon detection. The wearable device also sends its stored history of vitals and timestamps for PTSD episodes to the phone when available.

### The Phone Application

A phone application sends configuration information to the wearable. This allows the user to turn off and on the device. The application communicates with the wearable via Bluetooth when available. This application is NOT required for the main functionality of the wearable itself.

### Functionality

The wearable device and the feedback device combine to provide the core functionality of the system. The user will depend on this system when they leave their home with their service animal. This means that the platform exists in every context that the veteran leaves home. Utilizing a wearable device attached to the user's wrist provides access to measure multiple vitals (cardiovascular activity, respiratory system activity, nervous system activity). Additionally, if the user needs to discreetly interact with the device, it is in a location that is almost always easily available. Using a simple interface for interacting (buttons, a small screen), the user can quickly complete their interaction and return to their prior activity.

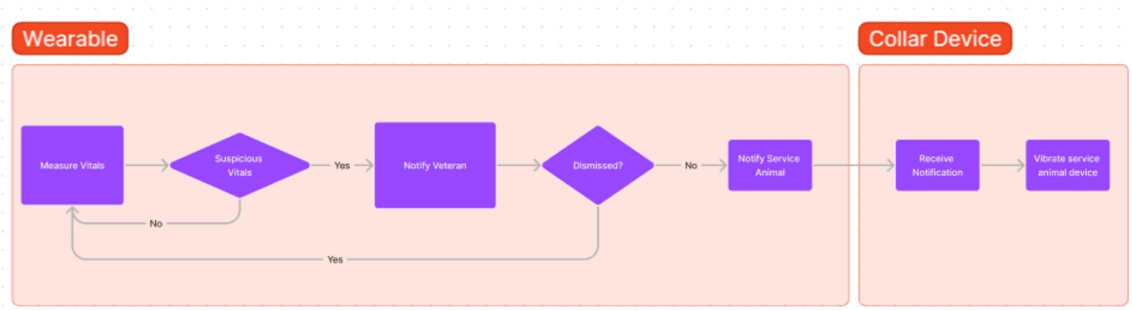


Figure 4.7.1.2: Device operation flowchart

Our design will satisfy the requirement to make sure that the alert feature for the dog is subtle. We plan to use vibration, which is one of the most subtle options for an alert. Most likely, only the dog will be alerted, and potentially, a bystander near the dog will notice. Additionally, our intended form for the wearable is to be a wrist-worn device and, therefore, subtle.

## 4.7.2 Design 1 (Design Iteration)

Design Visual and Description

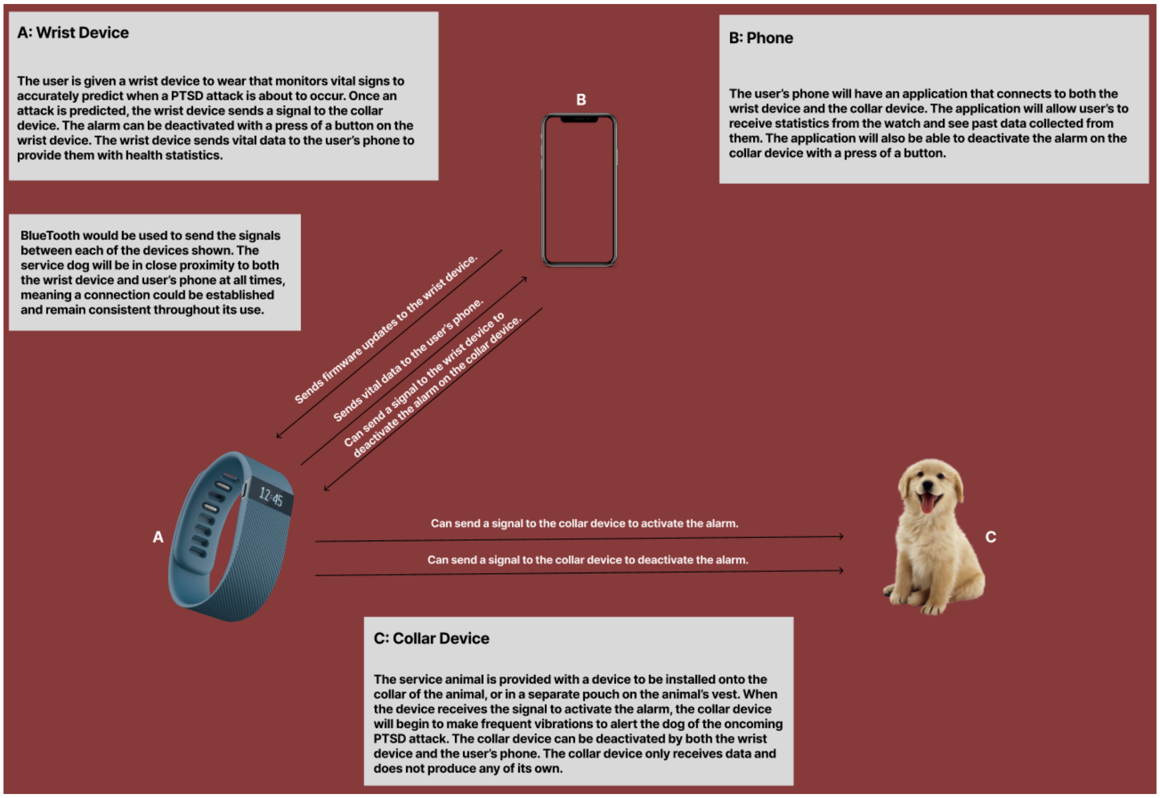


Figure 4.7.2.1: Design 1 diagram

### Changes from Previous Iteration:

This design iteration builds on the previous initial design by outlining the key features that each device will have as well as how they will interact with each other. The core devices mentioned within the diagram are the Wearable Device, Feedback Device, and Phone Application.

## 4.7.3 Design 2 (Design Iteration)

### Changes:

Following Design Iteration 1, we identified several unsolved problems. Firstly, there is no data available to us for designing any kind of algorithm for predicting the onset of symptoms. Additionally, relying on a phone for dismissing alerts, and interacting with the device causes another point for breakdown in the system. The phone could die, be incompatible, or have numerous other issues beyond our control. This caused us to attempt to create an iteration of our design more decoupled from the phone.

To solve these issues, we decided to break the device into multiple design stages. The lack of available physiological data on PTSD symptoms currently presents a significant challenge for designing any algorithm for predicting the onset of symptoms. Additionally, the main goal of Agile (our main project management style) is to produce shorter development cycles, more frequent releases, and allow early feedback. Below is an outline of each design stage:

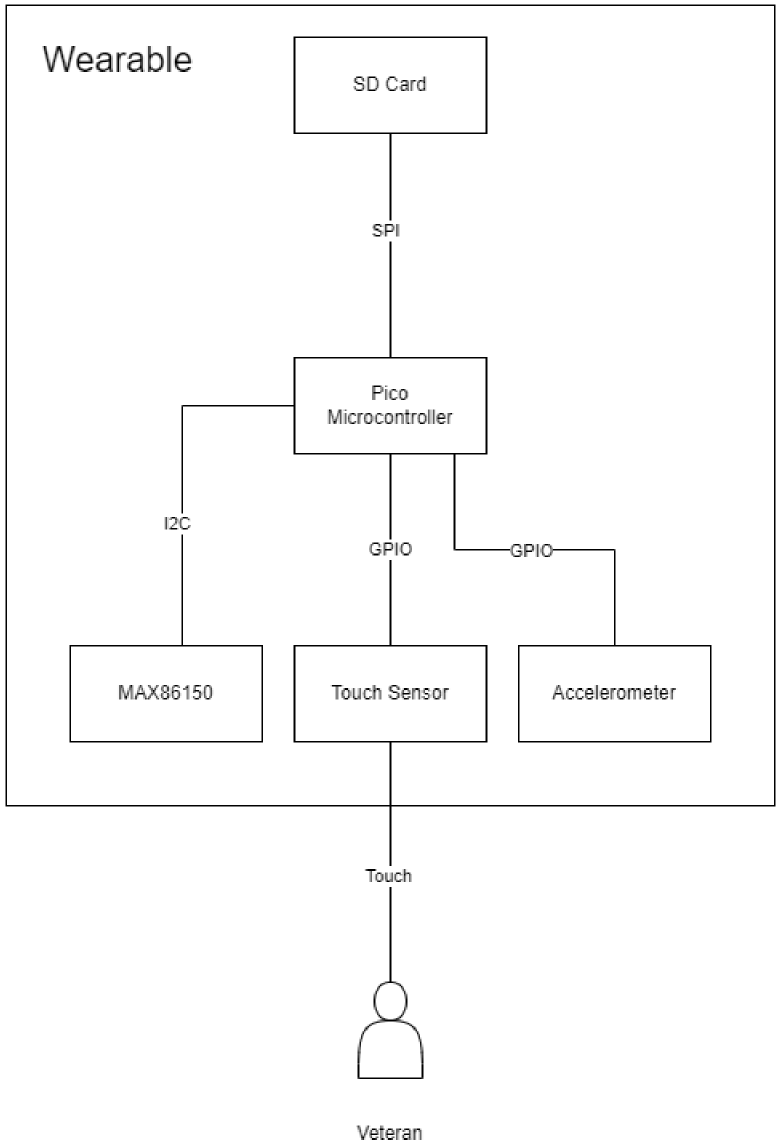


Figure 4.7.3.1: Design Stage 1: Wearable for data collection

In the first stage our device will collect data. We will design a device that stores vitals and event timestamps (on a button press). This will be distributed to Vetdogs, and we will collaborate with them in the collection of PTSD episode data.

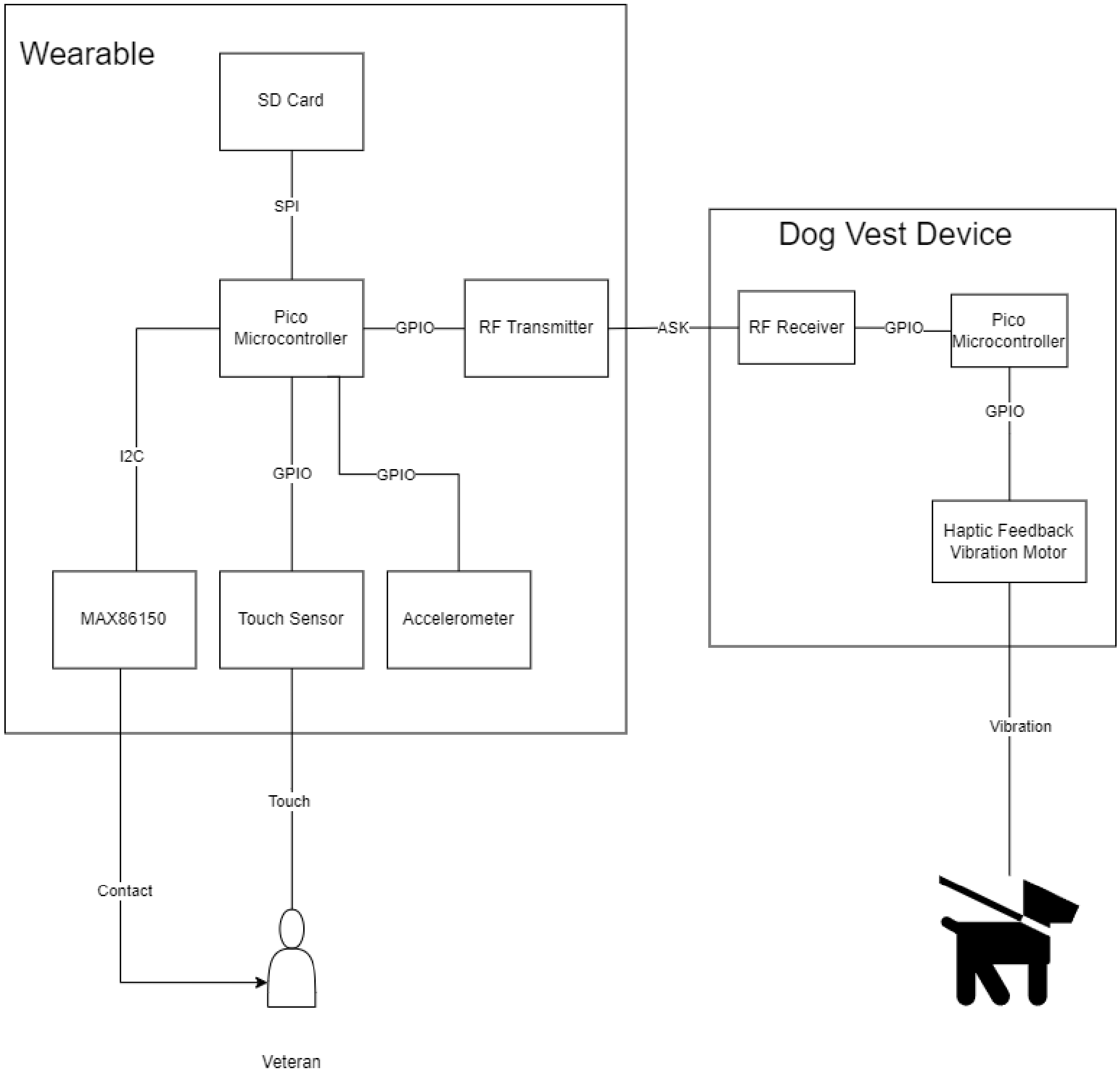


Figure 4.7.3.2: Design Stage 2: Wearable with dog feedback device

In the second stage, we design the dog feedback device, an initial/simple algorithm for PTSD episode symptom prediction, and integrate a means of communication with this onto the wearable device. This stage should collect data, predict PTSD episodes, and alert service animals. The algorithm will be designed using data collected from the first design stage.

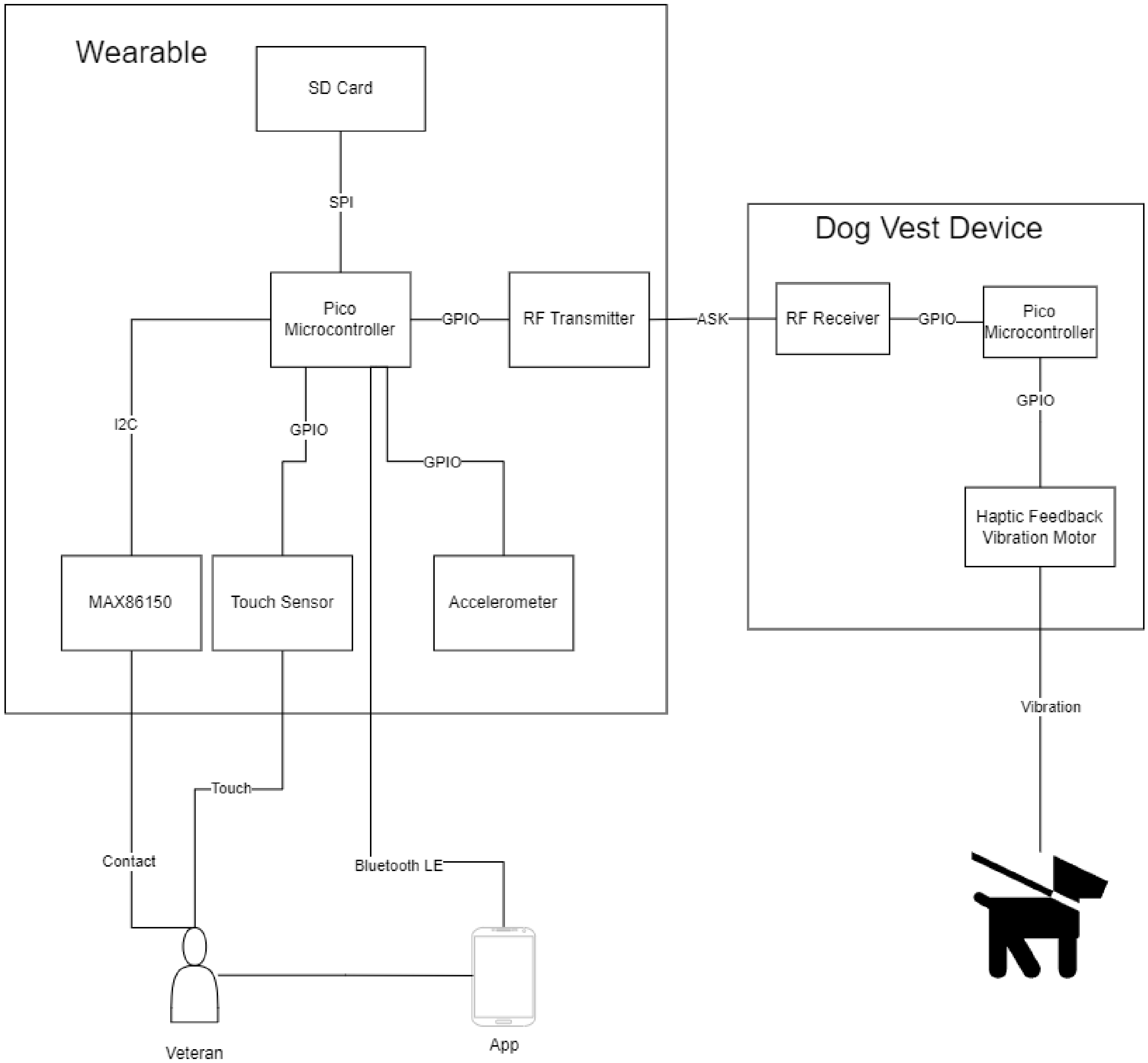


Figure 4.7.3.3: Design Stage 3: Integration of app with wearable

The final design stage integrates an app/UI with the wearable. This stage provides the user with the ability to synchronize the app with the wearable and turn off/on the device.

### 4.8 Technology Considerations

Bluetooth benefits:

- Connections are long-lived
- Supported by many platforms

Bluetooth limitations:

- Short range
- Requires authorization/handshake

Radio benefits:

- Simple, no handshake
- Longer range

Radio drawbacks:

- More custom work
- Less established procedure

Mobile benefits::

- More processing power
- Built-in support/frameworks

Mobile drawbacks:

- Different hardware by phone
- No custom RF
- Potential compatibility issue

### 4.9 Design Analysis

As of now, our team does not have any definitive test results to conclude if any of the mentioned designs function correctly or not. With that said, we have many ideas for potential additions to the design for functionality purposes if our current design is successful:

- Implementing additional sensors - there is research on the usefulness of cortisol levels and skin conductivity in measuring stress levels, so we have our eyes on them as a possibility for future feature expansion.
- Add sensing for electro-dermal activity (EDA). Electrodermal activity is a measure of sympathetic nervous system activity, and is reflected as of skin conductance. EDA has been clinically proven as a direct indicator of stress.
- Implementation of a mobile app - this is discussed elsewhere in the document. Display data and act as a control interface that users are already familiar with.

# 5 Testing

In our first iteration of the project, we chose to focus on collecting more data than the standard on-the-market smartwatch and provide an easy interface for VetDogs to be able to collect the data and send it to our team for analysis and usage. This design consists of a wearable device with an IC that records red, IR, and green light reflections from the skin, as well as the state of a toggle button, then stores the data to an SD card. The VetDogs workers can then mount the SD card to their computer and send the data to our team, allowing for a quick review and collection of data for the iterative development of an algorithm for detecting PTSD episodes. A quick feedback loop allows for significantly faster iterations of the wearable device design and provides us quick benchmarks for device accuracy, usefulness, and, most importantly, a quick user-feedback loop.

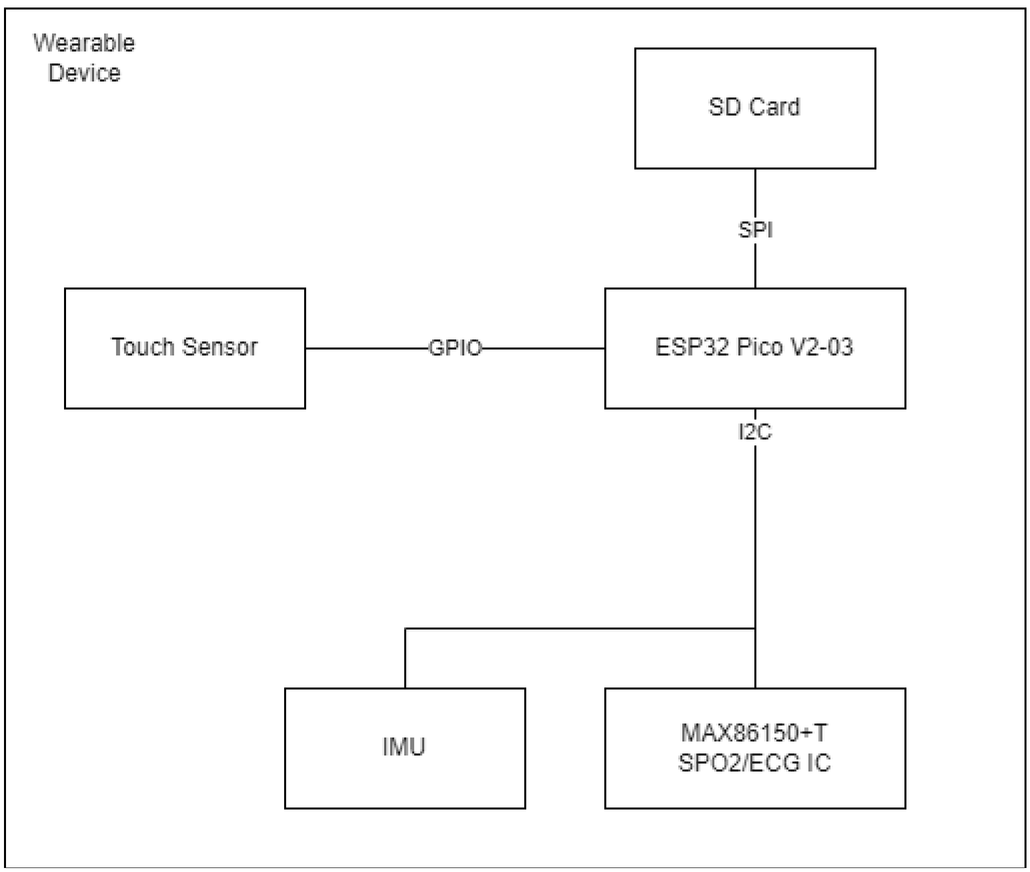


Figure 5.1: Testing Setup

## 5.1 Unit Testing

<u>Wearable Device Components:</u>

### MAX SPO2/cardiac output sensor:

- Does the sensor output voltage match the requirements for the ESP Pico? Use a Voltmeter or oscilloscope to test.
- Does the sensor output (after converting/processing) match an actual SPO2 sensor?
- Does the sensor output match an actual heart rate detector?
- We can also use the available firmware and dev kit for the MAX device to test our configuration in real time.

### Notable values and acceptable ranges to look for in testing:

- 40-60 bpm is consistent with bradycardia (lower end of about 0.666 Hz).
- 200 bpm is approximately the upper-end normal "maximum" for a 14-year-old. (upper end of 3.333 Hz).
- Peaks in the blood-flow volume graph should be between 0.666 Hz and 3.333 Hz, depending on the situation.
- SPO2 (if below 95% medical intervention is recommended, the normal amount is between 95%-100%) Acceptable range is between 95 and 100.
- Sensors output voltage within appropriate minx/maxes for the sensor. No current or voltage spikes, shorts, or otherwise harmful phenomena. (sensor component), test by writing output data to logs.

Should be tested in both low-stress (control) environments as well as higher-stress environments, with supervision.
Use a pulse oximeter (FDA-approved) to provide "proper" values at an interval and qualitatively compute calculations based on the sensor output.
Sensors should be tested on students before being sent to VetDogs for further testing.

### Accelerometer:

- Check that output is within the acceptable range.
- Check values match a usable, compressible format for the Microcontroller.

### ESP32 Pico Microcontroller:

- Assuming the MAX sensor provides valid values over I2C, the data is parsed and prepared to be written to a file.
- Assuming the button works properly, while the toggle is active, the data output marks the data as PTSD episode active. Otherwise, the data is marked as false (not active).
- Given proper sensor data input, the microcontroller encodes the data in Protobuf format with consistent schema (microcontroller data processing component)

**SD card:**

- Data persists after the microcontroller turns off or the card is removed
- Data/files are visible when attached to a computer.

**Touch sensor toggle (button):**

- On startup, the sensor output is low,
- When the sensor output is high, the output remains high.
- On being pressed again, the sensor output is low until the sensor is pressed again.

## 5.2 Interface Testing

**User - MAX:**

- Use provided firmware and similar devices to verify sensor data.
- Use an oscilloscope to record sensor output and compare with example data from other studies.

**MAX over I2C to Pico:**

- Outputs to file and verify the file data.
- Assert sensor readings are within the reasonable range.

**Touch sensor - GPIO - Pico:**

- Output to file and verify manually.

**Pico - SPI SD card protocol - MicroSD card:**

- Write file to SD card, plug SD card into computer, read manually.
- Write file to SD card, read file from SD card.

## 5.3 Integration Testing

**MAX sensor output is written to SD card:**

- Activate wearable device, attempt to read from SD card files, if file does not exist then there is an issue on this path.
- Check the data read from the file, if it contains continuous cardio/respiratory data, then pass, otherwise if missing data, or wrong/corrupt data then fail.
- Hardware can be simulated with CEEFIT or FIT frameworks in C, then we can test the integrations with software, without the hardware working (yet)

**Touch Sensor → SD card:**

- Activate wearable device, attempt to read from SD card files, if file does not exist then there is an issue on this path
- Check data is read from the file, if it contains continuous data for toggle then good, otherwise if corrupt/missing values, then the test fails.
- After running tests using CEEFIT or the prototype device, we can plot the data and verify validity by checking for outliers. The firmware for the MAX can be used to provide graphs of what the data should look like.

## 5.4 System Testing

- Writes/processing of data from the sensor's process in live-time (within 20 ms per sample). This would provide an upper-level benchmark for success in sampling.
- Test what battery life/voltage the device has a performance/quality drop-off. Use voltage transformers in Coover to modify input voltage until the device performance drops.

- Microprocessor resource usage does not have spikes. Performance is sufficient to maintain consistent, reliable data. We can investigate OSQuery, system calls (by OS), or drivers to log system performance and add warnings for issues.

## 5.5 Regression Testing

All future system enhancements will be external additions. As an illustration, our team has contemplated a mobile application to establish a connection with the wearable device; however, it has been temporarily set aside to prioritize the development of the wearable and feedback devices. If the internals of our devices end up being upgraded or switched out for any reason, we refer to section **5.1** in regard to testing the new components.

Any modifications made to our wearable and feedback devices will solely be made to make the system more functional and reliable to use. In order to test that these changes are working correctly, we will verify the output of the system through the system logs.

Automating testing using FIT frameworks can abstract the hardware design.

By using software/simulation-based testing frameworks, we can require tests to pass before approving any changes, insertions, or modifications.

## 5.6 Acceptance Testing

**First Prototype:**

The first prototype is to verify our hardware and give us a basis for iteration to meet final requirements. Our goal is to capture and save sensor data reliably in a simple version of the device.

**Requirement:** Capture and save sensor data to SD card

- All unit, integration, and system tests pass
- After unit and integration tests, send prototypes to America's VetDogs to test with veterans. We have already discussed the possibility of this with them.

While wearing the device, accurate vitals and sensor readings are read and stored on an SD card. Veterans at VetDogs can be provided with the device, partnered with a monitoring person, and the data of their vitals and any episodes is stored on the SD card. Monitoring staff writes down the start and end times of PTSD episodes for our team's later verification. The VetDogs staff then email the data from the SD card to our team. This provides direct user feedback for the wearable device size, design, and interface challenges in the form of comments.

Obtaining the data early provides us with a set of data to divide into training(development) and testing data. One partition of the data is used for developing an algorithm that predicts and detects PTSD episodes, the other is used to verify success by applying the algorithm across its values.

**Final design requirements and tests, not applicable to first prototype:**

**Requirement:** Reliably detect PTSD episodes.

- Input simulated PTSD episode data and ensure that the device detects them.
- Have the device worn by someone prone to episodes and verify that it detects their episodes as they occur.

**Requirement:** Able to disable

- Simulate/trigger device and disable with button and/or app.

**Requirement:** Feedback device is not disruptive

- Trigger the feedback device and ensure that it is not noticeable by humans.

By obtaining quick feedback from veterans, we will be informed early on in the process of discomfort with the device, challenges with the wearable device buttons/interfaces, and obtain samples of their "normal" and "elevated" vitals.

### 5.7 Security Testing (if applicable)

While the Phone Application is a background idea for the time being, it is important to plan ahead in case it becomes a priority in the future. Due to the nature of phone applications, security testing is important as to not allow any breaches in user data. As such, the tests we plan to put into place are as follows:

- Testing the encryption of data transmission via our communication protocols (Bluetooth).
- Ensuring that the firmware for the microcontroller and sensors are up to date.
- End-to-end encryption of vitals can be ensured via digital signatures. Man-in-the-middle attacks can test this.

### 5.8 Results

At this time, we do not have any results. Initial prototypes are in the works and are thus not able to produce results for the time being. In the future, we are hoping to send our wearable device prototype to America's VetDogs veterans so that they can collect data on PTSD episodes. This data can be used to create an algorithm for which to detect oncoming PTSD episodes.

# 6 Implementation

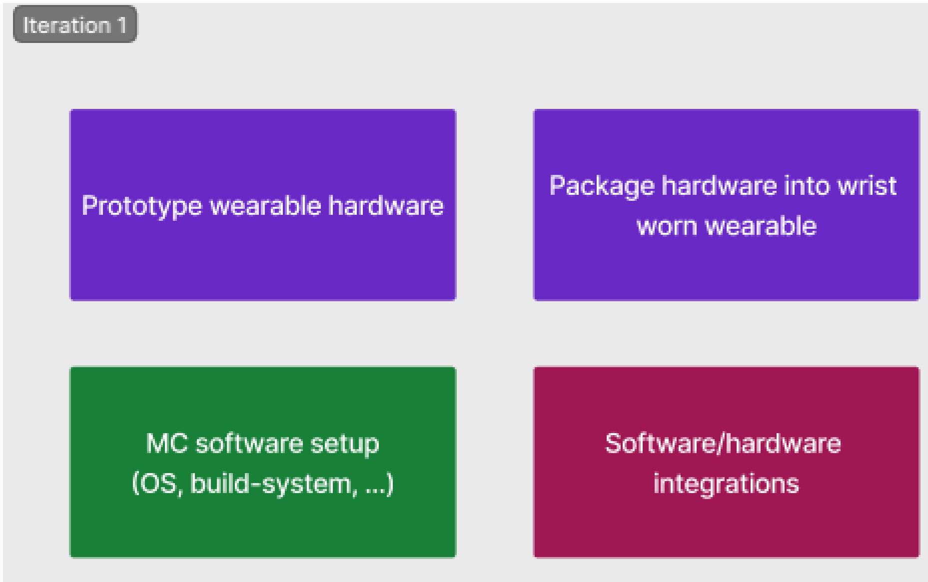


Figure 6.1: Hardware Iteration 1

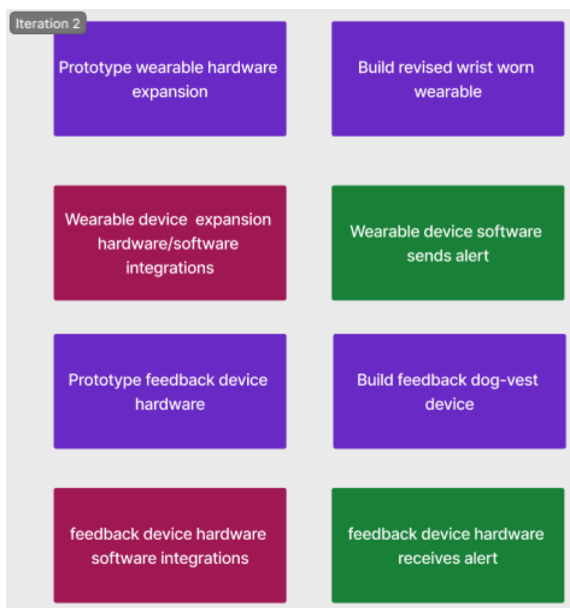


Figure 6.2: Hardware Iteration 2

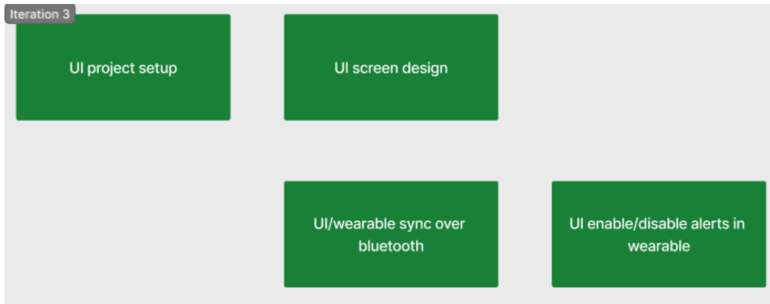


Figure 6.3: Hardware Iteration 3

We broke down our device into 3 main iterations that we can release/ship to Vetdogs throughout the project.

The first release will focus on reading and collecting physiological and environmental data. This will be shipped to Vetdogs and we will collaborate with them to obtain data that is usable for development of a second release.

The second release involved providing an early/warning and advanced feedback system for alerting the service animal of an imminent PTSD episode. In this release we focus on detecting abnormal data consistent with episodes, the feedback device, and the connection between the devices.

The last release will be focused on user interactions with the device. The user will be able to dismiss PTSD episode alerts if they are not correct, turn off and on alerts from the wearable device, and perform various configurations.

Following each release of the device and software, we will receive feedback from the test group at Vetdogs and use the feedback to adapt our product to best meet our clients' needs.

# 7 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

## 7.1 Areas of Responsibility

Table 7.1.1: Areas of Responsibility

| **Professional Responsibility Area** | **SE Code of Ethics Principle that relates** | **Description of how the principle relates** |
|---|---|---|
| Work Competence | PRODUCT 3.01 | PRODUCT 3.01 and Work Competence are related because both principles revolve around providing the highest quality product in the most efficient time period. |

| | | |
|---|---|---|
| Financial Responsibility | PUBLIC 1.07 | PUBLIC 1.07 and Financial Responsibility are related because both principles say to keep the end price of the created product affordable to those that need it. |
| Communication Honesty | PUBLIC 1.06 | PUBLIC 1.06 and Communication Honesty are related because both principles say to avoid deception within statements made. PUBLIC 1.06 is related more to public statements, but the principle applies for private statements as well. |
| Health, Safety, Well-Being | PRODUCT 3.08/3.10 | PRODUCT 3.08/3.10 and Health, Safety, and Well-Being are related because both principles are put in place to prevent damage/injury to the user of the product. PRODUCT 3.08/3.10 relates to the software portion of damages, while Health, Safety, Well-Being is for more life-threatening instances. |
| Property Ownership | CLIENT AND EMPLOYER | CLIENT AND EMPLOYER and Property Ownership are related because both principles say to respect the ideas and principles provided by a client or any higher authority to your project. |
| Sustainability | PUBLIC 1.04 | PUBLIC 1.04 and Sustainability are related because both principles refer to the potential damage done to the environment because of the usage/manufacturing of the provided product. |
| Social Responsibility | PUBLIC 1.02 | PUBLIC 1.02 and Social Responsibility are related because both principles are meant to protect the common interests of the public, and dissuade against any public disturbances. |

### 7.2 Project Specific Professional Responsibility Areas

Table 7.2.1: Project Specific Professional Responsibility Areas

| **Professional Responsibility Area** | **Does it apply to our Project's Professional Context?** | **How well is the team performing?** |
|---|---|---|
| Work Competence | Yes; The goal of our project is to create a high-quality prototype of a device that can be used by veterans and those affected by PTSD, and thus needs to meet the highest standards of quality. | (Medium) Our team strives to produce the highest quality of work, but sometimes falls short due to time constrictions and group scheduling conflicts. |
| Financial Responsibility | Yes; The outcome of this project should be a device that is affordable for those who need it. Design decisions are made with that idea in mind. | (Medium) As the project moves forward, more additions are made to the device making it less and less affordable. More design research can be done to find alternative parts for the design. |
| Communication Honesty | Yes; Any work that is shown or communicated to advisors/clients is shown with full-honesty. Nothing is withheld or kept secret from those who proposed this project. | (High) The team has done an excellent job of conveying the truth in any discussions we had with advisors/our client. Status reports are provided with accurate recaps of what happened during the previous week of work. |
| Health, Safety, Well-Being | Yes; This project is based around a device worn by an individual and a device worn somewhere on a service animal. Because of this, our team needs to keep in mind the safety/risk factors when designing devices meant to be in close contact to a person/animal's skin. | (High) Within design phases of this project, the team has used caution when deciding on sensors to ensure that they do not cause a potential threat to a user's life or the lives of those around them. Future testing will show if those design decisions hold true. |
| Property Ownership | Yes; When working with our advisors/clients, it's important that we respect any and all suggestions they have for us. We have chosen to work on a project they proposed to us, and thus we need to show them respect for their vision. | (High) When meeting with advisors/clients, our team uses polite mannerisms and respectful discussions to hear what our advisor/client has to say. We take any feedback given and try to improve our work in respect to that advice. |
| Sustainability | Yes; The designs for our device are aimed to be environmentally friendly in terms of material. The purpose is to help others while also making a product that can be produced without providing an ecological threat. | (N/A) As stated our designs have environmental friendliness in mind, but we do not have specifics on materials at this time. |

| | | |
|---|---|---|
| Social Responsibility | Yes; This product is meant to assist those struggling with PTSD episodes, thus making their lives more fulfilling in the process. | (High) Our team has spent time researching methods of communication with the feedback device that will not intrude on the lives of those around the user and their service animal. |

### 7.3 Most Applicable Professional Responsibility Area

The most applicable Professional Responsibility Area for this project is 'Health, Safety, Well-Being.' Due to the nature of this project, our team will be working with America's VetDogs veterans to collect biological data for an algorithm that will be used to further our designs. Because of this, the team needs to ensure that any prototypes being used by individuals outside of our team are tested extensively for any safety hazards. A device will also be used by the individual's service dog, which also needs to be extensively tested before use so as to not cause any harm to the animal. There are real lives involved with this project and as such needs to be taken as seriously as possible in terms of design and safety.

## 8 Closing Material

### 8.1 Discussion

The results of this semester's work were more than what our group was anticipating. Originally, our team had expected to have a list of parts to order between semesters and to begin prototyping at the start of next semester. In reality, the team managed to get parts ordered before the end of the first semester and plan on putting together a basic prototype before the second semester. Starting on this initial prototype early will play a large role in accomplishing our future goals for this project and give us a head start on the meat of this project.

### 8.2 Conclusion

Throughout this first semester, our team has worked to establish a starting point for our first prototype wearable device. We've researched various methods for collecting biological data and determined the best sensors to use for our first prototype. Our team has reached out to several sources in order to gain access to their biological studies on PTSD episodes, but so far have not received any responses.

Our current goals for the upcoming semester are to first establish a working prototype for our wearable device. From there, our team can send that prototype to America's VetDogs to be used by veterans to collect biological data on PTSD episodes. Once we have the raw data, the team can break it down into an algorithm that will be used to determine whether or not the user is suffering from a PTSD episode while wearing the wearable device. This algorithm will allow the team to move to the creation of the first feedback device prototype, which will work alongside the wearable device to alert a service dog to their owner's incoming PTSD episode. If possible, our team would like to create a phone application to work alongside the wearable and feedback devices to show biological statistics to the user.

In order to achieve these goals, our team needs to create a wearable device prototype as soon as possible. Our goals rely on the biological data received from veterans using the wearable device, and without that data, we are unable to move forward with the project. Our team's biggest constraint for accomplishing these goals is scheduling conflicts and a lack of biological data to work from. For our team to work more efficiently, we would need to either receive responses from those we reached out to for data or go off of hypothetical data to construct a potential algorithm for our wearable device.

### 8.3 References


Sadeghi M, McDonald AD, Sasangohar F (2022) Posttraumatic stress disorder hyperarousal event detection using smartwatch physiological and activity data. PLoS ONE 17(5): e0267749. https://doi.org/10.1371/journal.pone.0267749

Gilbert, Stephen B.; Civitate, Anthony; Kelly, Jonathan W.; Thompson, Frederick; Smith, Alisha; Kopecky, Ken; Winer, Eliot; and de la Cruz, Julio, "Comparing Training Performance With Vibrotactile Hit Alerts vs. Audio Alerts" (2013). Industrial and Manufacturing Systems Engineering Conference Proceedings and Posters. 91. http://lib.dr.iastate.edu/imse_conf/91

T.-Y. Li, W.-C. Tsai, and S.-F. Lin, "Non-invasive Recording of Parasympathetic Nervous System Activity on Auricular Vagal Nerve Branch,"


### 8.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

MAX86150EFF+T Integrated Photoplethysmogram and Electrocardiogram Bio-Sensor Module For Mobile Health Data Sheet: https://www.analog.com/media/en/technical-documentation/data-sheets/max86150.pdf

ESP32-PCIO-V3-02 microprocessor Data Sheet: https://www.espressif.com/sites/default/files/documentation/esp32-pico-v3-02_datasheet_en.pdf

BOM for our initial prototyping: https://docs.google.com/spreadsheets/d/1UOIC1i2b3jDDD9kekGfiEX9gX-gHquo_/edit#gid=1140817152

#### 8.4.1 Team Contract

**Team Members:**

1). Casey Halbmaier

4). Ben Gardner

2). Coby Konkel

5). Andres Ceballos

3). Caden Backen 6). Nihaal Zaheer

## Team Procedures

1. **Day, time, and location (face-to-face or virtual) for regular team meetings:**

   **Weekly TA Meetings:** *Mondays 2:00 PM - 2:30 PM (Senior Design Lab, Coover Hall)*
   **Weekly Team Meetings:** *2:30 PM - 3:00 PM (TLA, Coover Hall, or SIC)*

2. **Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):**

   In person for essential meetings, discord for most communication outside of meetings, with email as a backup. Virtual meetings through discord if needed.

3. **Decision-making policy (e.g., consensus, majority vote):**

   Consensus if possible, if not agreeing within 30 minutes, Vote.

4. **Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):**

   Google Spreadsheet minutes for each meeting, taken by whoever is present.

## Participation Expectations

1. **Expected individual attendance, punctuality, and participation at all team meetings:**

   Presence at all meetings is expected if available, and clear and timely communication about absences and tardiness is required.

2. **Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:**

   All members are responsible for completing assigned work on time and asking for help and communicating issues when needed.

3. **Expected level of communication with other team members:**

   Respond within the same day to Discord messages. Ping is important.

4. **Expected level of commitment to team decisions and tasks:**

   When you say you're going to do something, we will assign a date to finish by. Do your best to get done by then, if challenges exist preventing you from meeting the deadline communicate it. For hard deadlines, consistent communication and work to meet the deadlines is mandatory.

## Leadership

1. **Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):**

   **Project Manager:** Casey Halbmaier
   *Drive the team towards productivity. Hold team members accountable for commitments, and orchestrate internal/external communication.*
   **Scrum Master:** Ben Gardner
   **Technical Lead:** Coby Konkol
   *Drive integration of the technical various team members. Ensure team-wide synchronization for technical tasks, help in any role that is falling behind.*
   **Software Design:** Caden Backen
   *Responsible for the patterns, architecture, and implementation of software, both for the algorithm (for early PTSD detection) and in the hardware.*
   **Hardware Design:** Ben Gardner and Andres Ceballos
   *Design and implement physical design. Work with any sensors, wires, ICs, or any other hardware requirements for the wearable device and feedback device.*
   **Interfacing Team Lead:** Nihaal Zaheer
   *Establish communications between the sensors (SPI, I^2C, GPIO, MQTT …), microcontroller, dog vest device, and phone.*

2. **Strategies for supporting and guiding the work of all team members:**

   Everybody has their own strengths and skills. Make it clear to everybody your strengths and lend support to each other.

3. **Strategies for recognizing the contributions of all team members:**

   Task tracking through Gitlab. Tasks assigned to specific individuals will be marked as such and, when completed, will be marked as such.

## Collaboration and Inclusion

**1. Describe the skills, expertise, and unique perspectives each team member brings to the team:**

**Ben:** *Experience writing C for embedded systems and schematic drawing. Worked on a professional development team.*

**Casey:** *Experience in Java, C, and JavaScript programming languages. Organized and cooperative in a team.*

**Nihaal:** *Prior experience with debugging and writing code for hardware. Good with Linux, Containers, Docker, Bash, C, Python.*

**Coby:** *Good with Linux, containers, cloud infrastructure, DevOps, APIs, backend, data/pipelines. Most comfortable with Java, Python, C, Bash scripting. History making apps*

**Caden**: *Experience with Python, C, Java, Matlab, Simulink. Job experience with large scale machinery, specifically embedded systems.*

**Andres:** *Autodesk inventor, CAD, Quartus Prime, Creo Draft, Circuit Design, and beginner level in C.*

**2. Strategies for encouraging and supporting contributions and ideas from all team members:**

- Don't shoot down ideas right away.
- Have good-faith discussions of all ideas.

**3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)**

- Depending on the situation, a group discussion would be used to bring up the issue.
- If the situation is a severe issue where threats have been made, the individual will reach out to other members of the team and the TA for action steps moving forward.

**Goal-Setting, Planning, and Execution**

**1. Team goals for this semester:**

- Learn new skills for designing projects given specific criteria.
- Develop communication skills between the team and the client.
- Become familiar with one another so that everyone is understood.
- Develop teamwork skills to prepare ourselves for next semester.

**2. Strategies for planning and assigning individual and teamwork:**

- Work assigned to individuals according to skill and current workload. Will attempt to balance workload based on schedules and availability (if someone has more non-project commitments, accommodation will be made)

**3. Strategies for keeping on task:**

- Gitlab issues
- Reminders of tasks and deadlines and progress updates during meetings

**Consequences for Not Adhering to Team Contract:**

**1. How will you handle infractions of any of the obligations of this team contract?**

- Talk to the team members and try to resolve it internally.
- Seeking guidance from TAs

**2. What will your team do if the infractions continue?**

- TA first
- If the problem continues reach out to the professor

*************************************************************************

**a) I participated in formulating the standards, roles, and procedures as stated in this contract.**

**b) I understand that I am obligated to abide by these terms and conditions.**

**c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.**

1) Casey Halbmaier DATE 9/8/2023

2) Coby Konkel DATE 9/8/2023

3) Caden Backen DATE 9/8/2023

4) Ben Gardner DATE 9/8/2023

5) Andres Ceballos DATE 9/8/2023

6) Nihaal Zaheer DATE 9/8/2023