BAE SYSTEMS

PTSD Detection Device

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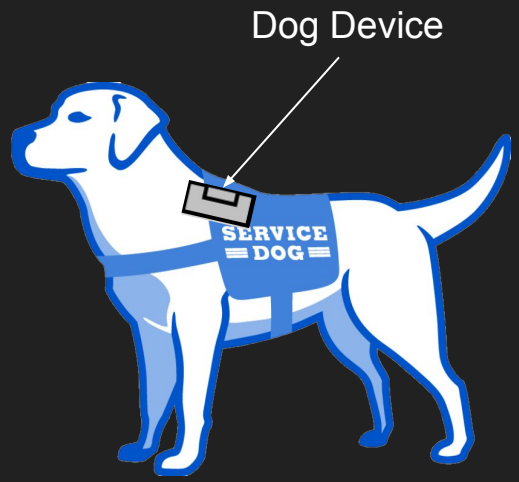
Group 08

Client: BAE Systems & America's VetDogs

Advisor: Mohamed Selim

Project Vision

- Project Purpose: Close the response time between the detection of PTSD in a service dog to treating the human companion.
- Users: 1) Human Companion 2) Service Dog
- User Needs:
  - Structurally and functionally discrete
  - Comfortable
  - Faster dog alert than normal dog senses
  - Enough battery lifetime for a day of use
- Project Solution: Utilize and integrate common consumer technology with our own device and mobile software.



High Level Conceptual/Visual Sketch

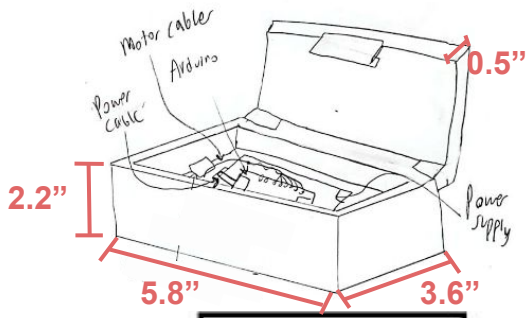
System Diagram

Smart Watch

- Transmits measured biometric data from human to phone via Bluetooth (ex. heartbeat)

Phone

- Collects data from smart watch
- Interprets said data via an algorithm designed to determine PTSD attacks from recieved data
- Transmits signal to dog device via Bluetooth IF a PTSD attack is detected

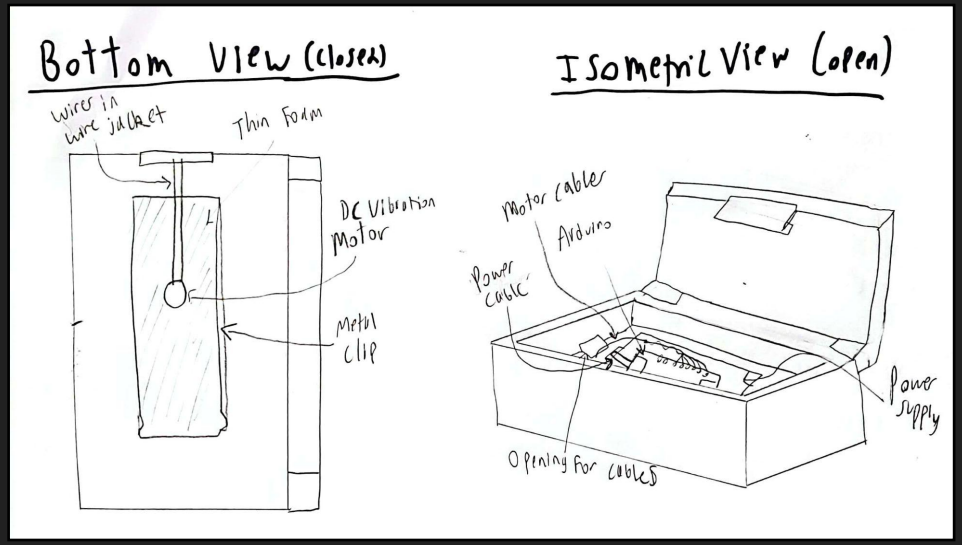


Dog Device

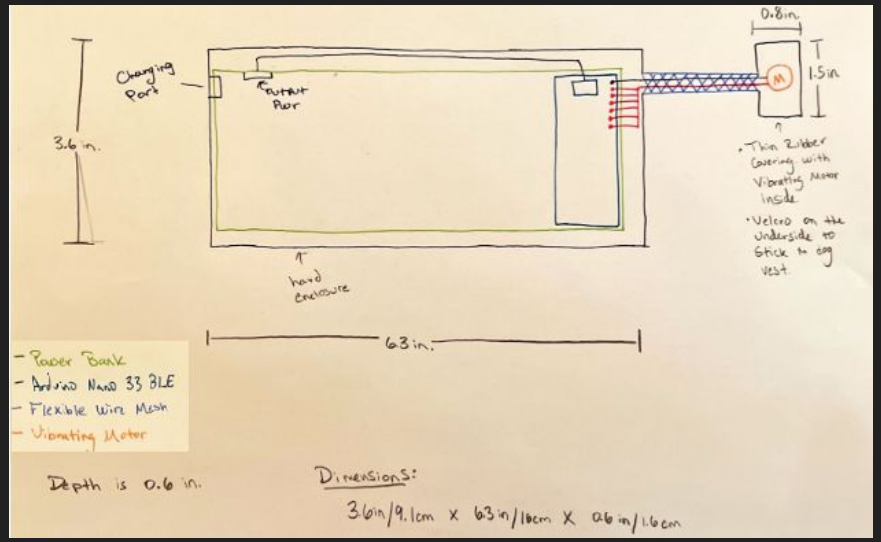
- Alerts dog via vibration motors once a PTSD signal has been recieved and processed
- Fixed to vest of service dog

High Level Conceptual/Visual Sketch Continued…

Dog Device Hard Form Factor



Dog Device Soft Form Factor



Requirements

- **Functional**
  - App must be able to run on any mobile operating system
  - Must track and send data to the Dog’s device
  - Stable Bluetooth connection
  - Devices must be able to turn off during exercise
- **Non-functional**
  - Adjustable for differents types of people and dogs
  - Device does not hurt the dog
  - Affordable to most people
- **Technical and/or other constraints**
  - Light weight

Engineering Standards

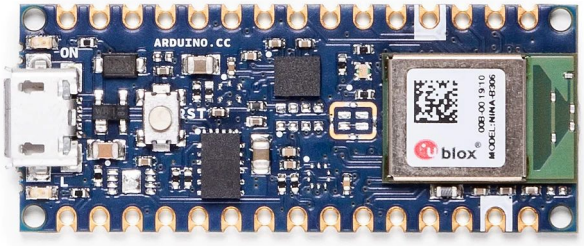
- **IEEE 802.15.6:** Wireless Body Area Network (WBAN)
- **IEEE 802.15.1-2005:** Bluetooth and Bluetooth Low Energy (BLE)
- **IEEE 1725-2006:** Rechargeable Batteries for Cellular Telephones
- **IEEE 12207:** Systems and Software Engineering – Software life cycle processes
- **IEEE 7002-2022:** Data Privacy Process

Conceptual Design Diagram

A high level diagram of the design approach

System Design

- **Hardware Design:**
  - Arduino Nano 33 BLE Microcontroller
  - 3 Volt Vibration Motors
  - Bluetooth connection to Apple Watch
  - 5 pins per vibration motor utilized to provide current



Arduino Nano 33 BLE

Vibration Motor

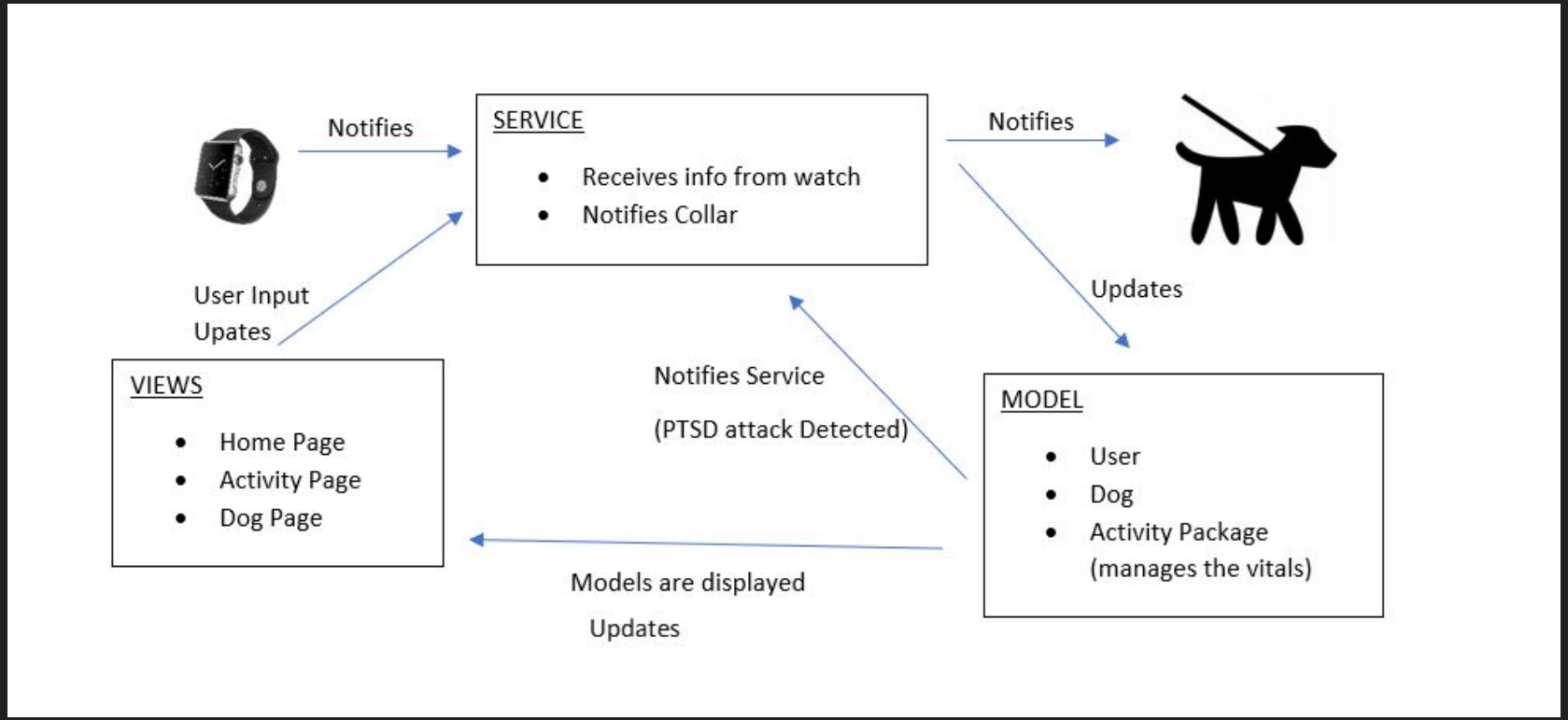
System Design

- Embedded System Design:
  - System architecture initializes all pins to output
  - Bluetooth connection establishment
  - Configuration Mode
  - Program Start
  - Main program will listen for messages from bluetooth line
  - When an attack is in progress, device will turn activate vibration
  - When attack has been subdued, the device will deactivate vibration

System Design

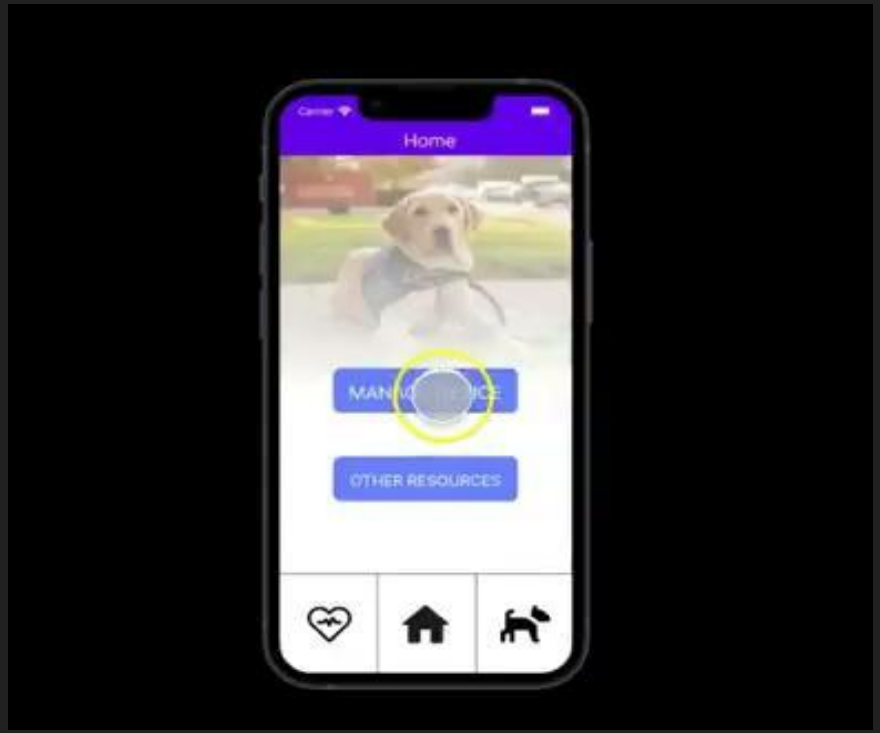
- Software Design (Mobile App)
  - Built using Flutter Framework
  - Follows an MVC pattern
  - A service to communicate with other systems (dog collar and smart watch), communication is done via FlutterMethodChannels and flutter_bluetooth_serial package.
  - Views will include Home Page, Activity Page, and Dog Page
  - Models will include User, Dog Info (dog collar), and Activity.
  - StateControllers are in Flutter StatefulWidgets, ActivityController will be managed in the Activity Model itself.
  - Cached Information will be managed via Flutter HiveBox
  - Machine Learning incorporated in the PTSD detection algorithm

System Design



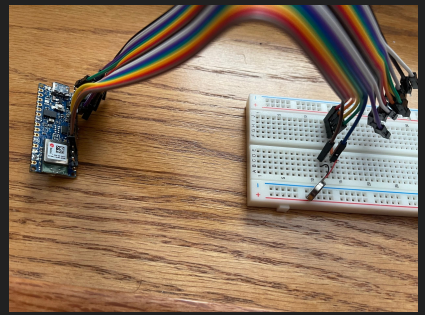
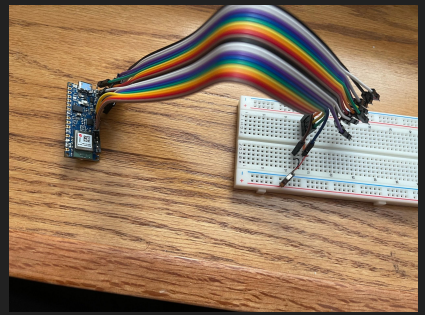
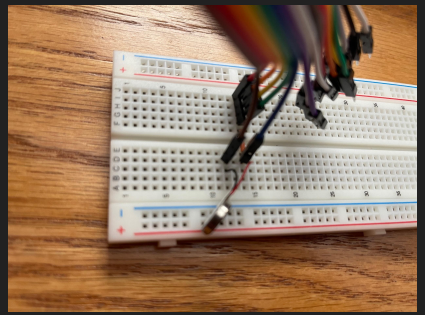
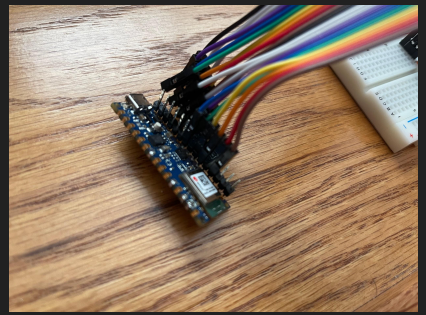
System Design

- UI/UX Design (Mobile App)



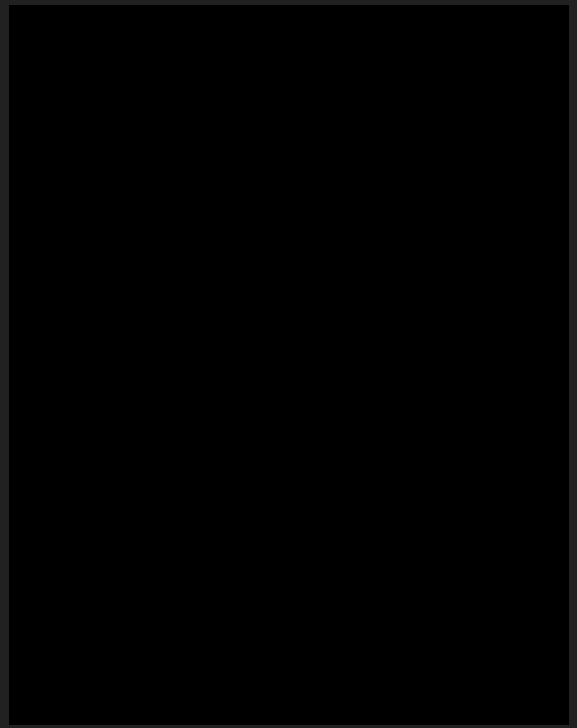
Prototype Implementations

- First Hardware Prototype:
  - Arduino Nano 33 BLE Soldered to breadboard pins
  - Male to female breadboard jumpers bridging ground and microcontroller pins to breadboard
  - Breadboard containing ground jumper and all 5 output pins in parallel
  - Vibration motor positive cable connected to line of parallel output pins
  - Vibration motor ground connected to breadboard ground linked to arduino ground
  - Proof of concept with solid connections for programming inter device communication

Prototype Implementations

- Software Prototype:
  - Basic UI elements have been implemented
  - Custom elements can be changed later
  - Graphs for activity display have been added
  - Navigational flow works



Design Complexity

- Hardware Complexity:
  - Difficulty connecting devices to Arduino pins without solder
  - Once connection was made, when vibration still wouldn’t engage
  - Tested with multimeters and the voltage was present, so faulty code ruled out
  - Tested with LED, and LED worked, until vibration motor connected in parallel
  - With this leading to current supply, tested vibration on power rail of arduino successfully
  - Began down the road of designing a mosfet low volt switch or finding a low volt relay
  - Had an idea to see if driving multiple pins in parallel would provide sufficient current
  - Built new prototype with 5 pins driving vibration and tested it successfully
  - With this new system, we have now established full code controlled vibration
  - Integration with bluetooth for remote control vibration is the next step

Design Complexity

- Software Complexity:
  - Maintaining connections to dog collar and apple watch
  - Reading and interpreting data in a timely manner
  - Incorporating new Flutter dependencies and tools (learning curve)
  - iOS development
  - Machine learning algorithms

- In Future Iterations:
  - UI/UX will continue to look cleaner
  - Continuously making the PTSD detection algorithm

Project Plan - Tasks

- **App**
  - **User Interface:** Design Theme, Main Page, Activity Page, Dog Management Page
  - **Backend:** API/Send-Receive Data, Connecting to devices, Cache Info, Database
- **Dog Device:** Breadboard, Arduino with bluetooth, Vibration motor, 5V source for power, Device enclosure
- **Connections:** Flutter app, phone, and watch
- **Iterations:** Update enclosure, PCB to remove jumper wire/breadboard connections

Project Plan - Risks and Mitigation

- Users may feel our system is intrusive (Risk Rating 0.7)
  - Configurability: allow features to be turned off and on, customizable
- Dog is uncomfortable or unresponsive to stimuli (Risk Rating 0.3)
  - Multiple iterations and testing of the device design
  - Allow user to adjust the vibration to best suit their dog.
- Device may incorrectly detect PTSD attack (Risk Rating 0.7)
  - Allow user to turn off the device during physical activity

Project Plan

- Market Research Work with Veterans
  - We have consulted veterans already for features they would potentially want
  - Continue to work with veterans to make necessary modifications as we begin our next iterations.

- Market Research Work with Dogs
  - BAE Systems will provide an opportunity to work with dog’s next semester
  - Ensure the dog’s device is comfortable and effective

Project Plan - Milestones

- UI allows user to reach all features
  - design/theme is beyond this milestone
- About 80% accuracy when detecting PTSD
- Response time from PTSD episode
  - Recognized and sent to dog device is less than a second
- Dogs are respond well to the device at least 90% of the time
- Design of sensors and hardware finalized

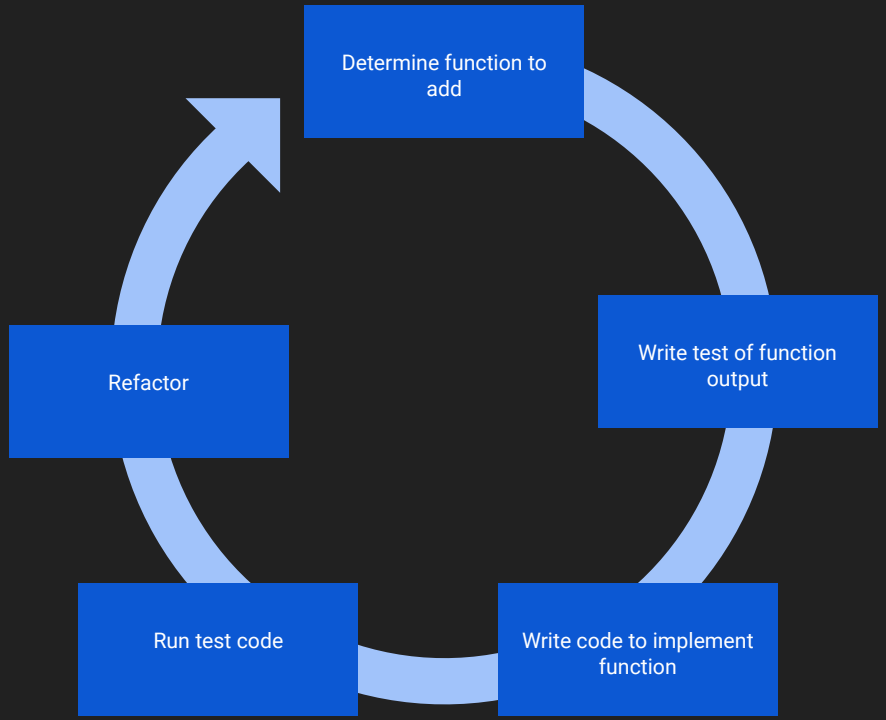
Test Plan - Component/Unit

- Vibration Motor
  - Run manual tests to feel if vibration motor is working.
  - Dog’s reaction time will be measured by a stopwatch.
- Battery
  - Lifetime of battery will be tested by using a voltmeter over an interval of time.
- Software
  - Implement multiple dart unit tests to test various use cases and functionality.
  - Simulate a user to ensure the flow of use case can be accomplished.
  - Mock objects to test the functionality of the sending, receiving and data storage between the 3 devices.

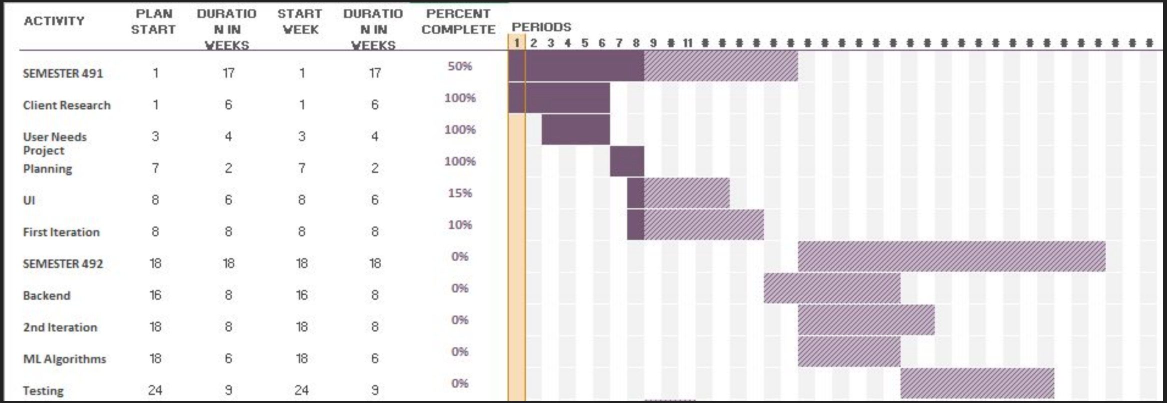
Test Plan - Interface/Integration

- App
  - Use of mock objects to test edge cases and various workloads.
  - Build unit tests to confirm user navigation works.
- Hardware
  - Verify there is a physical impulse from the motor when a signal is sent to it.
  - Bluetooth will be tested by writing a mock code to ensure the bluetooth connection is executing all functions and to ensure all sensors are functioning properly.
- System
  - Test the system as a whole, all components are sending and receiving data as expected.
  - Test use cases (turning on/off notifications, varying distances between systems, etc)

Test Process



Gantt Chart

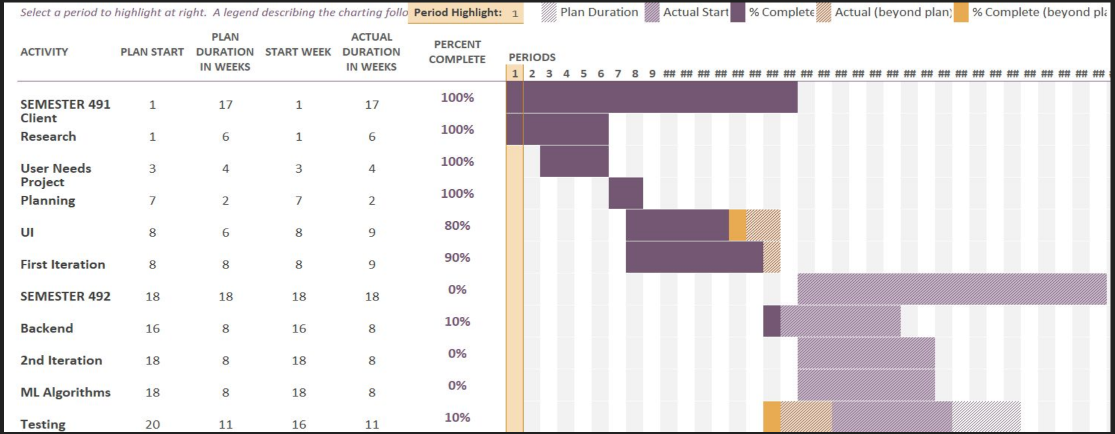


ACTIVITY	PLAN START	DURATION IN WEEKS	START WEEK	DURATION IN WEEKS	PERCENT COMPLETE
SEMESTER 491	1	17	1	17	50%
Client Research	1	6	1	6	100%
User Needs Project	3	4	3	4	100%
Planning	7	2	7	2	100%
UI	8	6	8	6	15%
First Iteration	8	8	8	8	10%
SEMESTER 492	18	18	18	18	0%
Backend	16	8	16	8	0%
2nd Iteration	18	8	18	8	0%
ML Algorithms	18	6	18	6	0%
Testing	24	9	24	9	0%

← Original Timeline

Updated Timeline →

- Needed more time for UI and 1st iteration
- Changed testing and machine learning time



Select a period to highlight at right. A legend describing the charting follo **Period Highlight:** 1 Plan Duration Actual Start % Complete Actual (beyond plan) % Complete (beyond pla

ACTIVITY	PLAN START	PLAN DURATION IN WEEKS	START WEEK	ACTUAL DURATION IN WEEKS	PERCENT COMPLETE
SEMESTER 491	1	17	1	17	100%
Client Research	1	6	1	6	100%
User Needs Project	3	4	3	4	100%
Planning	7	2	7	2	100%
UI	8	6	8	9	80%
First Iteration	8	8	8	9	90%
SEMESTER 492	18	18	18	18	0%
Backend	16	8	16	8	10%
2nd Iteration	18	8	18	8	0%
ML Algorithms	18	8	18	8	0%
Testing	20	11	16	11	10%

Conclusions

- This semester
  - Fell behind schedule with the hardware as we discovered 1 pin wouldn’t be enough to power the motor.
  - On schedule for everything else

- Next semester
  - Bluetooth Connection
  - Continue UI work
  - Create enclosure and test on the dog vest

Questions?