# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, Richard Taylor

# FINAL REPORT

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# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, and Richard Taylor

# CONCEPT OF OPERATIONS

REVISION - 2
30 April 2022

# Concept of Operations
# for
# IoT Based Pet Tracker

Team <17>

Approved by:

__________________________________
Project Leader Date

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Prof. Kalafatis Date

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T/A Date

# Change Record

| Rev. | Date | Originator | Approvals | Description |
|---|---|---|---|---|
| **-** | 02/09/2022 | IoT Based Pet Tracker | | Draft Release |
| **1** | 02/23/2022 | IoT Based Pet Tracker | | Revision 1 |
| **2** | 04/30/2022 | IoT Based Pet Tracker | | Revision 2 |

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# List of Figures / Tables

# 1. Executive Summary

The purpose of this project is to address the problem of finding a pet whenever it is lost. The solution specified is to design and develop a GPS tracking system attached to the collar of a pet. On the collar there will be a GPS, camera, buzzer and LED. The GPS system and camera will communicate to an internet database which will then communicate to an android app. Through the app, the user will have the ability to set the dimensions of a safe area for the pet, request video streaming from the collar, and receive notifications when the pet is out of the specified safe zone. The buzzer and LED will be activated whenever the GPS detects that the pet has left the safe zone. Then the user will be notified via alert notifications from the app that their pet has escaped. By using the IoT Based Pet Tracker, the user should be able to locate and return their pet home safely.

# 2. Introduction

The Internet of Things (IoT) based pet tracker will perform a variety of features to enhance pet safety and monitoring. Many scenarios arise where pets compromise their safety by escaping or going into unsafe areas. By using the IoT based pet tracker, users can find the location of their pets whenever and wherever with the use of an Android app.

## 2.1. Background

Common measures for pet safety in place today include chipping—a practice where a chip containing the owner's information is inserted into a pet—and using pet collars that may have GPS capabilities. While these methods are effective, they are limited in their ability to efficiently locate pets. For example, chips only work by relying on the person who found the pet to take them to the pound and many GPS trackers do not report the exact location of the pet.

The IoT based pet tracker aims to improve the user's ability to find precious pets with the touch of an app. This can be used in tandem with chipping so users can find their pets while it's on the run or even after someone has brought it in to check the chip at a pound. It will also be helpful to be used along with a normal label and phone number on a dog collar. A bystander may notice your pet with the device lighting up and making sound and decide to call the number so you can get them back. This system will be able to replace other dog GPS trackers that have less features and overall usefulness than our tracker.

## 2.2. Overview

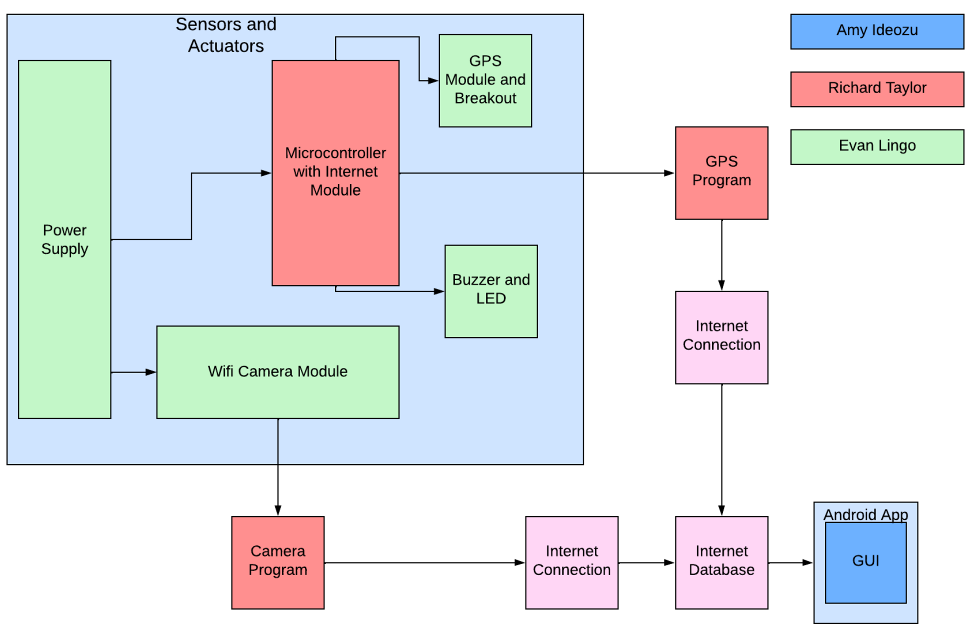


*Figure 1: IoT Based Pet Tracker System Block Diagram*

This system will be used to track the activities of a user’s pet as it goes about its day to day life. There are three main subsystems involved in the IoT based pet tracker. The first subsystem is the system of sensors and actuators which will read input from the environment and send it to the internet database via the microcontroller. By detecting GPS signals, the sensors will be able to send data as well as accept inputs from the microcontroller to actuate the LED and buzzer. The second subsystem will be the microcontroller and Wi-Fi camera system which will act as a middleman between the Android app and the first subsystem for the project. The microcontroller will contain all the code to accept and send GPS data to the graphical user interface (GUI) via an online database as well as accepting and sending input to the LED and buzzer to ensure the whole project runs smoothly. The Wi-Fi camera will be separately programmed to send video feed to the user via an IP when requested. The last subsystem is the Android app which will enable the user to monitor the activity of the tracker from their phone. It will have a variety of features including daily and weekly reports on pet activity, an option to check the video stream of the camera on the tracker, and an ability to set the bounds of the safety net for the pet.

## *2.3. Referenced Documents and Standards*

- Using GPS/Location Services: https://developer.android.com/training/location

# 3. Operating Concept

## 3.1. Scope

This project would affect the market of dog and cat owners that are concerned about the safety and behaviors of their pets. The IoT based pet tracker will be able to interface with multiple users through an internet database which will communicate with the Android app. As long as the consumer has an android phone, a pet, and stable internet connection in their house, they will be able to set up the IoT based pet tracker.

## 3.2. Operational Description and Constraints

The project will be used for the recreational purpose of security of pets. By checking daily and weekly activities users can be sure that their pet is staying within the bounds of its designated safe zone most of if not all of the time. By ensuring the location of the pet through the GPS system as well as additional security methods such as the video camera, LEDs, and buzzer sounds, you will be reassured that their pet is out of harm's way. Checking up on your pet will only require checking the easy to use phone app.

The constraints of the system are as follows

- The GPS, microcontroller, LED, buzzer, Wi-Fi camera, and power supply will be attached to the collar of the pet on a PCB with a Wi-Fi module to connect it to the internet database
- The Android app will run on your phone.
- The phone app will be connected to the internet database and thus will be able to communicate with each other.
- The cost for the design will be affordable for the average pet owner.
- Time for development will be limited to 13 weeks.
- The device will not be waterproof but instead will be water resistant.

## 3.3. System Description

- Android App: Will act as the user interface for the device, enabling the user to set the safe area, request video streaming for the collar, and receive notifications when the pet is out of the safe zone. This will be connected to an internet database that will be connected to the Wi-Fi camera module as well as the microcontroller.
- Wi-Fi Camera: Takes video input to send through internet connection to the database and then to the user's phone app.
- Buzzer: Will activate and remain active as long as the pet is outside of the safe zone.
- LED: Will activate and remain active as long as the pet is outside of the safe zone.
- GPS module: Will record the location of the pet through GPS and provide feedback to the app via the microcontroller.
- Microcontroller: Will be connected to the GPS module, LED and buzzer on the PCB board and then will be connected to the internet database via a Wi-Fi module.

### *3.4. Modes of Operations*

The IoT based pet tracker will have two modes as well as an extra function that can be activated in either mode. The first mode will be INACTIVE in which the pet is inside the safe zone and thus the LED and buzzer will not be activated. In this mode, users will still be able to check the GPS location of their pet through the Android app. The second mode will be ACTIVE in which the pet is outside the safe zone and thus the LED and buzzer will be activated. In this mode, the user will receive notifications about their pet being outside the safe zone once every 30 minutes or so. In either mode the user will be able to use the Android app to check the video feed from the pet’s collar.

### *3.5. Users*

The IoT based pet tracker will be marketed to pet owners of dogs and cats of age 18 and above. It requires a basic understanding of replacing batteries for the system as well as basic knowledge about using the Android app. Many pet owners who are worried about where their pet may be at any given point in the day will benefit from using the pet tracker.

### *3.6. Support*

Support for the IoT based pet tracker will come in a troubleshooting guide as well as a user manual. The user manual will encompass all the basic guidelines for using the system such as replacing the batteries and the basics for downloading and using the Android app.

# 4. Scenario(s)

## *4.1. Pet outside safe area*

Once the pet is outside the safe area, the user will be notified via alerts on their phone. These alerts have to be manually turned off to ensure that the user is aware that their pet is outside of the defined safe area. At that point the user can choose to activate the video camera located on the collar. Additionally, the buzzer and LED on the collar will automatically be activated once the pet has left the safe area.

## *4.2. User request video camera*

The user can request video whenever needed. It is not limited to only when the pet is outside of the safe area. However, the video will not always be streaming; the user must request the video stream via the app.

## *4.3. Redefining safe area*

The user has the option to redefine the dimensions of the safe area for the pet. In the scenario where the user wants to take their pet to the park, they will be able to set the dimensions of the safe area to the park they are at. This ensures that the user is not limited to only one safe area.

## *4.4. GPS Malfunction*

In the case that the GPS malfunctions or is not transmitting data to the user, the user can still request video feed from the collar. It is not an ideal situation, but there are still ways that the pet can be found. The buzzer and LED will not be activated as there will be no way to determine whether the pet is inside or outside of the safe zone.

## *4.5. Wear and Tear*

In the event that the collar experiences any sort of wear and tear, including, but not limited to: exposure of the PCB boards, exposure of the battery, internal water damage, and/or physical damage inflicted on the collar, the user should remove the collar and dispose of it to protect their pet from any harm.

# 5. Analysis

## *5.1. Summary of Proposed Improvements*

- Allow users to track and see the location of their pet at all times via phone app.
- Application will allow users to use geofencing to set “safe zones” for the pet.
- Provide visual and audio cues to alert user that pet is out of bounds and help user to locate their pet:
  - Video camera streams by user request.
  - LED and buzzer sound when the pet leaves the area.

## *5.2. Disadvantages and Limitations*

- No theft protection; the collar can be removed from the pet by anybody at any time
- App failure due to:
  - Slow/no network connection.
  - Blocking bugs in the program.
  - Disconnection from collar.

## *5.3. Alternatives*

- Bluetooth, but this requires that the collar and the raspberry pi that is in the house is within approximately 30 feet. While Wi-Fi can connect up to approximately 1000 feet.
- Chipping pet, but requires the person who found the pet to go to a Veterinarian's office.
- Pet trackers that are already out in the market (but do not have video streaming capabilities):
  - Standard trackers: allows GPS signal only.
  - Hunting trackers: GPS tracking and buzzer to have.

## *5.4. Impact*

Because the pet tracker collects video footage, there may be privacy concerns. There is also an environmental issue with the materials used due to having a lithium ion battery, while considered to be more eco-friendly than other batteries. Some of the positive impacts include being able to find your lost pet and knowing where your pet is at all times.

# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, Richard Taylor

# FUNCTIONAL SYSTEM REQUIREMENTS

REVISION – 1
30 April 2022

# FUNCTIONAL SYSTEM REQUIREMENTS
FOR
# IoT Based Pet Tracker

APPROVED BY:

______________________________
Project Leader Date

______________________________
John Lusher, P.E. Date

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T/A Date

# Change Record

| Rev. | Date | Originator | Approvals | Description |
|---|---|---|---|---|
| - | 02/23/2022 | IoT Based Pet Tracker | | Draft Release |
| - | 04/30/2022 | IoT Based Pet Tracker | | 1 |

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## List of Figures / Tables

# 1. Introduction

## *1.1. Purpose and Scope*

The IoT Based Pet Tracker (IPT) aims to supplement pet security and monitoring by enabling pet owners to be more proactive. The system will use GPS, video streaming, visual and aural cues, and an Android app to help users track the wellbeing of their pets from wherever they might be, given that the user is connected to the internet.

The IPT consists of three main subsystems: the sensors and actuators, microcontroller, and graphical user interface (GUI) contained in the form of an Android application. The system of sensors and actuators will include a Wi-Fi enabled video camera, GPS module, buzzer, and an LED. The microcontroller will act as a bridge between the sensors/actuators and Android app. Finally, the Android app will provide a simple and intuitive GUI for users to receive and request information from the tracker unit.

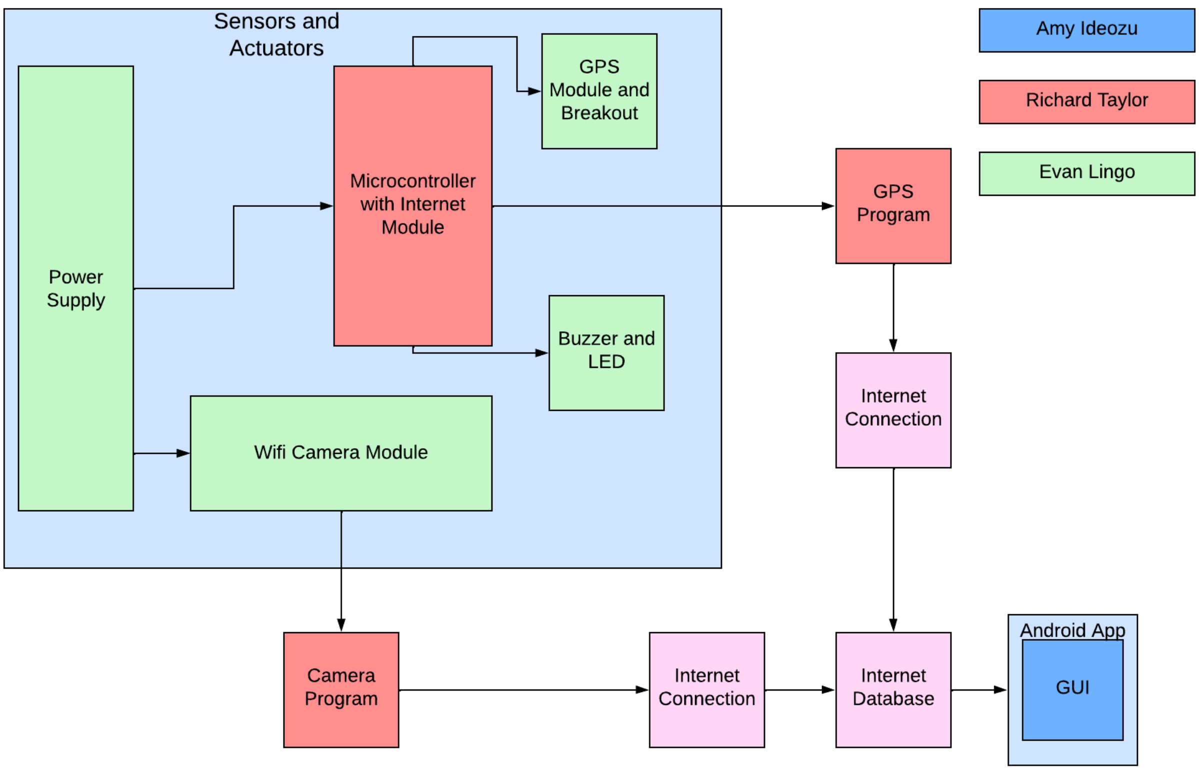


*Figure 1: Block Diagram of the IPT*

From the above figure, the sensors and actuators make up the tracker unit that will be placed on the pet. It will have an internet module to enable wireless communication with the internet database. The internet database will receive and send data between the tracker and Android app. Finally, the Android app will allow the user to see the location of their pet(s) and define safe zones, request video footage from the tracker, and alert the user when their pet leaves a safe zone.

## *1.2. Responsibility and Change Authority*

The team leader, Evan Lingo, will be responsible for making sure all the requirements set by the sponsor, Souryendu Das, are met. Any changes that are to be made to the product deliverables and/or specifications must be approved by the aforementioned team leader and sponsor.

Additionally, each team member is responsible for developing the following subsystems:

- Subsystem #1 (Sensors and Actuators): Evan Lingo
- Subsystem #2 (Microcontroller): Richard Taylor
- Subsystem #3 (GUI): Amy Ideozu

# 2. Applicable and Reference Documents

## *2.1. Applicable Documents*

The following documents, of the exact issue and revision shown, form a part of this specification to the extent specified herein:

| **Document Number** | **Revision/Release Date** | **Document Title** |
|---|---|---|
| IEEE 802.11 | 2012 | IEEE Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks - Specific Requirements |
| IPC A-610E | Revision E – 4/1/2010 | Acceptability of Electronic Assemblies |
| C2 - 2017 | 2017 | National Electrical Safety Code(R) |
| ASME Y14.5 | 2018 | Standard for establishing symbols, definitions, and rules for geometric dimensioning and tolerancing |

## *2.2. Reference Documents*

The following documents are reference documents utilized in the development of this specification. These documents do not form a part of this specification and are not controlled by their reference herein.

| **Document Number** | **Revision/Release Date** | **Document Title** |
|---|---|---|
| Version 1.4 | May 2017 | SDI-12 A Serial-Digital Interface Standard For Microprocessor-Based Sensors |
| SLAS800 | March 2013 | TI MSP430 microcontroller data sheet |
| ESP8266 | November 2014 | Sparkfun Wi-Fi Module - ESP8266 |
| Version 1.4 | October 2013 | Sparkfun GPS Receiver - EM - 506 |
| ANSI C119.6-2011 | 5 May 2011 | Electric Connectors--Non-Sealed,Multiport Connector Systems Rated 600 Volts Or Less for Aluminum and Copper Conductors |
| NFPA 70 | 6 Aug 2019 | National Electrical Code |

## *2.3. Order of Precedence*

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence without any exceptions.

All specifications, standards, exhibits, drawings or other documents that are invoked as “applicable” in this specification are incorporated as cited. All documents that are referred to within an applicable report are considered to be for guidance and information only, except ICDs that have their relevant documents considered to be incorporated as cited.

# 3. Requirements

## 3.1. *System Definition*

The IPT is a reliable system that will allow users to be able to track their pets. Users will be alerted whenever their pet has exited the defined safe area, which will activate the LED and buzzer on the pet's collar. It will also allow the user to see where their pet is via a Wi-Fi camera module that can be activated at any time. The IPT three subsystems are as follows: Sensors and Actuators, Microcontroller, and GUI.

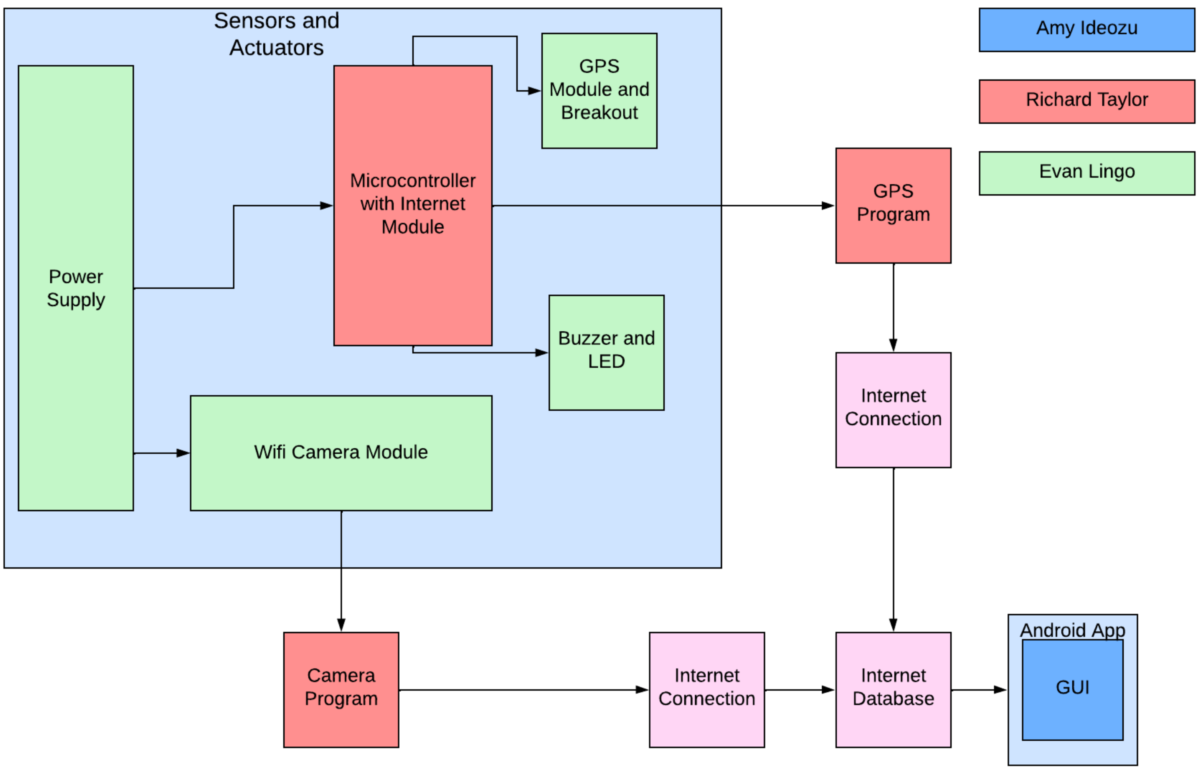


*Figure 2: Block Diagram of System*

## 3.2. *Characteristics*

### 3.2.1. Functional / Performance Requirements

#### 3.2.1.1. Battery Operating life

The IPT should have a battery life of at least 8 hours.

> *Rationale: Having a long battery life (for lithium batteries) will be more convenient for the pet owner to charge at leisure.*

#### 3.2.1.2. Time to Alert

The IPT should be able to alert the owner via LED + buzzer and phone notification within a minute of the pet exiting the safe area.

> *Rationale: The IPT should be able to alert the owner quickly so that the pet cannot get too far outside the safe area before it is lost. Having a quick alert will lessen the chance that the pet gets injured or lost before the owner is able to find it.*

#### 3.2.1.3. Geofence Size

The IPT will have a minimum geofence size of 100 sq. ft and a maximum size of 3600 sq. ft.

> *Rationale: The IPT should have a fairly large minimum size as the GPS may not be specific enough to designate a safe zone between a small size. The size should be a maximum of 3600 sq. ft because that would be the limit of the average Wi-Fi signal.*

#### 3.2.1.4. Video Stream Quality

The IPT will have video stream quality of 480p.

> *Rationale: The IPT should have fairly decent video quality so the user will be able to see what is going on.*

### 3.2.2. Physical Characteristics

#### 3.2.2.1. Mass

The mass of the IPT shall be less than or equal to 213 grams.

> *Rationale: The IPT should be fairly light so it doesn't discomfort the pet while it is being worn*

#### 3.2.2.2. Size

The volume of the IPT shall be less than or equal to 1.5 inches in height, 2 inches in width, and 3 inches in length.

> *Rationale: The size of the IPT should be fairly small so it doesn't discomfort the pet while it is being worn*

#### 3.2.2.3. Mounting

The IPT sensor and actuator subsystem will be mounted on the pet's collar to enable precise monitoring of the pet. The Android app will be downloaded onto the user's device.

> *Rationale: The system should be mounted onto the pets' collar so that it will monitor the pet properly. The android app will be downloaded to the user's device for easy accessibility.*

### 3.2.3. Electrical Characteristics

#### 3.2.3.1. Inputs

As long as the inputs for the IPT are functioning within the limits of the ICD, it will not malfunction or have a reduced life expectancy.

*Rationale: Having the IPT not malfunction as long as it is within the limits of the ICD will be beneficial to the user.*

**3.2.3.1.1.** Power Consumption

The maximum peak power of the system shall not exceed 3 watts.

*Rationale: The peak power consumption should be low so that it can run efficiently for long periods of time.*

**3.2.3.1.2.** Input Voltage Level

The input voltage level for the IPT shall be +1.8 to +3.6 VDC.

*Rationale: The Input voltage should be set to an appropriate level so that it does not mess up the system.*

**3.2.3.1.3.** External Commands

The IPT will have an external command for requesting video via the Android phone app.

*Rationale: The IPT will need video streaming to check on the location of their pet.*

#### 3.2.3.2. Outputs

**3.2.3.2.1.** Data Output

The IPT will output data through the MCU to the user’s Android phone app via the internet database.

*Rationale: The IPT must pass data through the internet system since it is an IoT based device.*

**3.2.3.2.2.** Output Voltage Level

The output voltage level for the IPT shall be 3.3VDC and 5 VDC.

*Rationale: The output voltage should be set to accommodate every sensor and actuator that needs to be powered in the system.*

**3.2.3.2.3.** Diagnostic Output

The IPT shall include a diagnostic interface for control and data logging.

*Rationale: Provides the ability to control things for debugging manually and a way to view/download the node map with associated potential targets.*

**3.2.3.2.4.** Raw Video Output

The IPT will include video streaming to the user's Android phone app via the Wi-Fi Camera.

*Rationale: Too much data to store internally.*

### 3.2.3.3. Connectors

The IPT shall use external connectors in accordance with American National Standard for Electrical Connectors ANSI C119.6-2011.

*Rationale: Conform to connector standard.*

### 3.2.3.4. Wiring

The IPT shall follow the National Electric Code guidelines or the NFPA 70 regarding electrical wiring.

*Rationale: Conform to wiring standard.*

### 3.2.4. Environmental Requirements

The IPT shall be designed to withstand and operate in the environments and laboratory tests specified in the following section.

*Rationale: The IPT will be fully functional when under normal environmental conditions.*

### 3.2.4.1. External Contamination

The IPT will be in a sealed container that has a charging port which will have a cover to prevent damage.

### 3.2.4.2. Rain

The IPT should not be exposed to water for large periods of time.

### 3.2.4.3. Humidity

The IPT will be resistant to humidity levels less than 50%.

### 3.2.5. Failure Propagation

The IPT System shall not allow propagation of faults beyond the IPT System interface.

### 3.2.5.1. Failure Detection, Isolation, and Recovery (FDIR)

**3.2.5.1.1.** Failure Detected

In any case that the IPT experiences failure to the hardware system that is beyond simple adjustments, then the user can send back the device to be repaired or replaced.

# 4. Support Requirements

The IPT will require an internet connection to enable communication between the different subsystems. Users must possess an Android device that has internet connectivity (Wi-Fi or mobile data). Additionally, the user must also be able to provide power to the tracker when it needs to be recharged. The IPT will come with one (1) tracker unit which consists of: one (1) battery, one (1) Wi-Fi camera, one (1) LED, one (1) buzzer, one (1) GPS module, one (1) MCU and one (1) Wi-Fi module. A power cable will also be included for recharging purposes. A collar will also be provided for tracker mounting purposes.

## • Appendix A: Acronyms and Abbreviations

| | |
|---|---|
| GPS | Global Positioning System |
| GUI | Graphical User Interface |
| ICD | Interface Control Document |
| IoT | Internet of Things |
| LED | Light-emitting Diode |
| mA | Milliamp |
| mW | Milliwatt |
| PCB | Printed Circuit Board |
| TBD | To Be Determined |
| IPT | IoT Based Pet Tracker |
| MCU | Microcontroller Unit |

## • Appendix B: Definition of Terms

## • Appendix C: Interface Control Documents

# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, Richard Taylor

# INTERFACE CONTROL DOCUMENT

REVISION – 1
30 April 2022

# Interface Control Document
# for
# IoT Based Pet Tracker

Approved by:

Project Leader Date

John Lusher II, P.E. Date

T/A Date

## Change Record

| Rev. | Date | Originator | Approvals | Description |
|---|---|---|---|---|
| **-** | 02/23/2022 | IoT Baser Pet Tracker | | Draft Release |
| **1** | 04/30/2022 | IoT Baser Pet Tracker | | 1 |

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## List of Figures / Tables

# 1. Overview

This document is provided to detail how the three subsystems, the sensors/actuators, microcontroller, and Android app, will interface to achieve the specifications outlined in the Function System Requirements document. The following sections will specify the requirements for each subsystem on three different aspects (where applicable): physical, electrical, and communications.

# 2. References and Definitions

## *2.1. References*

**ANSI C119.6-2011**
**Electric Connectors--Non-Sealed, Multiport Connector Systems Rated 600 Volts Or Less for Aluminum and Copper Conductors**
5 May 2011

**NFPA 70**
**National Electrical Code**
6 Aug 2019

**IEEE 802.11**
**IEEE Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks - Specific Requirements**
2012

**IPC A-610E**
**Acceptability of Electronic Assemblies**
1 April 2010

**C2- 2017**
**National Electrical Safety Code ®**
2017

**ASME Y14.5**
**Standard for establishing symbols, definitions, and rules for geometric dimensioning and tolerancing**
2018

**Version 1.4**
**SDI-12 A Serial-Digital Interface Standard for Microprocessor-Based Sensors**
May 2017

**SLAS800**
**TI MSP430 microcontroller data sheet**
March 2013

**ESP8266**
**Sparkfun Wi-Fi Module - ESP8266**
November 2014

**Version 1.4**
**Sparkfun GPS Receiver - EM - 506**
October 2013

## *2.2. Definitions*

| | |
|---|---|
| mA | Milliamp |
| mW | Milliwatt |
| GPS | Global Positioning System |
| GUI | Graphical User Interface |
| ICD | Interface Control Document |
| IoT | Internet of Things |
| LED | Light-emitting Diode |
| PCB | Printed Circuit Board |
| TBD | To Be Determined |
| IPT | IoT Based Pet Tracker |
| MCU | Microcontroller Unit |

# 3. Physical Interface

## *3.1. Weight*

The weight of the IPT will be about 213 grams.

## *3.2. Dimensions*

### 3.2.1. Dimension of MPU

The microcontroller will approximately be 14 mm by 14 mm.

### 3.2.2. Dimension of PCB

TBD

## *3.3. Mounting Locations*

The PCB and MCU system of sensors and actuators will be inside of a housing unit that will be mounted on the collar of the pet.

*Figure 1: Example of a housing unit attached to a collar.*

# 4. Thermal Interface

There will be heat sinks on the MCU and PCB to prevent overheating as it will run the tracking program to provide the location of the pet at all times. This will prevent it from overheating while running the video streaming program.

# 5. Electrical Interface

## 5.1. *Primary Input Power*

### 5.1.1. Wi-Fi Camera

The Wi-Fi camera will be connected directly to the power supply of 3.7V and will receive 3.3V through a buck/boost converter circuit.

### 5.1.2. MCU

The MCU will be connected directly to the power supply of 3.7V and will receive 3.3V through a buck/boost converter circuit. The MCU will also have four other components connected to it. The Wi-Fi module(3.3V), GPS module(5V), buzzer and LED(3.3V).

## 5.2. *Voltage and Current Levels*

**Maximum Values**

| Component | Voltage (V) | Current (mA) | Power (mW) |
|---|---|---|---|
| GPS Module EM 506 | 6.5 | 38 | 247 |
| Microcontroller MSP430FR60371IPZ | 4.1 | 2 | 8.2 |
| Wi-Fi Module ESP 8266 | 3.6 | 12 | 43.2 |
| Wi-Fi Camera module ESP 32CAM+ | 5 | 310 | 1550 |
| Arceli Buzzer | 5 | 30 | 150 |
| 5mm LED | 3.6 | 30 | 108 |

*Table 1: Maximum Voltage, Current and Power Levels*

The values of Table 1 are per second to allow for accurate gauging of power consumption at max power usage.

**Stand-By Values**

| Component | Voltage (V) | Current (mA) | Power (mW) |
|---|---|---|---|
| GPS Module EM 506 | 5 | 34 | 170 |
| Microcontroller MSP430FR60371IPZ | 3.3 | 2 | 7.2 |
| Wi-Fi Module ESP 8266 | 3.3 | 12 | 43.2 |
| Wi-Fi Camera module ESP 32CAM+ | 3.3 | 20 | 66 |
| Arceli Buzzer | 3.3 | 30 | 99 |
| 5mm LED | 3.3 | 20 | 72 |

*Table 2: Stand-By Voltage, Current and Power Levels*

The values of Table 2 are per second to allow for accurate gauging of power consumption at average power usage.

## *5.3. Signal Interfaces*

### 5.3.1. Signal interface for GPS

The GPS will be mounted on the PCB and controlled through the use of the MCU

### 5.3.2. Signal interface for Camera

The camera will also be mounted on the PCB but it will be controlled remotely via the Android app.

#### 5.3.3. Signal interface for Buzzer

The buzzer will be mounted on the PCB and controlled through the use of the MCU

#### 5.3.4. Signal interface for LED

The LED will be mounted on the PCB and controlled through the use of the MCU

## *5.4. Video Interfaces*

The video camera will be installed on the tracker device. The other video interface will be the Android app where the user will be able to watch live video from the device through the internet.

## *5.5. User Control Interface*

The control interface will be on the Android app. The user will be able to set a geofence for their pet within the guidelines as well as watch live video of the pet whenever they wish.

# 6. Communications / Device Interface Protocols

## *6.1. Wireless Communications (Wi-Fi)*

### 6.1.1. Wi-Fi

The internet module within the tracker uses the IEEE 802.11 b/g/n standard while the video camera uses the IEEE 802.11b/g/n/e/i standard. These connections will allow the devices to connect to the database, enabling communication to and from the different subsystems.

### 6.1.2. GPS

The GPS module with breakout will be connected to the Wi-Fi module to allow communication with the Android app.

## *6.2. Databases*

There will be two Firebase databases used—a Realtime database for User, Pet, Geofence, Tracker, and Camera information and an Authentication database for user account creation and information.

# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, and Richard Taylor

# EXECUTION AND VALIDATION PLAN

REVISION – 1
30 April 2022

# Execution Plan:

| | 02/25/22 | 03/04/22 | 03/11/22 | 03/18/22 | 03/25/22 | 04/01/22 | 04/08/22 | 04/15/22 | 04/22/22 | 04/26/22 | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (GUI) Setup Android Studio Project layout | | | | | | | | | | | 03/04/22 |
| (GUI) Functionality of creating geofences | | | | | | | | | | | 03/04/22 |
| (MCU) Camera web server on wifi signal | | | | | | | | | Not Started | | 03/05/22 |
| (S&A) Multisim Schematic | | | | | | | | | In Progress | | 03/11/22 |
| (MCU) Camera webserver on ESP 32 CAM wifi signal | | | | | | | | | Completed | | 03/14/22 |
| (GUI) Setup database for video streaming | | | | | | | | | Behind | | 03/25/22 |
| (S&A) Breadboard of multisim schematic | | | | | | | | | | | 03/25/22 |
| (MCU) GPS tracking basis created | | | | | | | | | | | 03/25/22 |
| (MCU) Testing of GPS tracking | | | | | | | | | | | 04/01/22 |
| (GUI) Setup database for geofencing | | | | | | | | | | | 04/01/22 |
| (S&A) Validation of breadboard | | | | | | | | | | | 04/01/22 |
| (GUI) Set triggers for notifications | | | | | | | | | | | 04/04/22 |
| (MCU) GPS data recording | | | | | | | | | | | 04/07/22 |
| (GUI) User database setup | | | | | | | | | | | 04/13/22 |
| (S&A) Design and creation of perfboard | | | | | | | | | | | 04/15/22 |
| (MCU) GPS program finishing touches | | | | | | | | | | | 04/17/22 |
| (GUI) Finalization of UI elements | | | | | | | | | | | 04/22/22 |
| (MCU) All MCU Programs are completely functional | | | | | | | | | | | 04/22/22 |
| (S&A) Finalization of perfboard | | | | | | | | | | | 04/22/22 |
| **Final System Demo** | | | | | | | | | | | 04/26/22 |

# Validation Plan:

| Paragraph # | Test Name | Success Critera | Methodology | Status | Responsible Engineer(s) |
| --- | --- | --- | --- | --- | --- |
| 3.2.1.1 | Battery Operating Life | Battery last for 8 hours | IPT is put in default operating state and left to run for 8 hours. Power will be monitored with connection on IPT | Not Tested | Evan Lingo |
| 3.2.1.2 | Time to Alert (GUI) | Notification sent to user's phone within one minute | Use stopwatch to measure the amount of time between pet leaving geofence/safe zone and the user being notified on their device | Tested | Amy Ideozu |
| 3.2.1.3 | Geofence Size | Geofence size is >=100 sq ft <=3600 sq ft | Phone application lets user choose a geofence size with a minimum radius of 100 sqft and maximum radius of 3600 sqft | Tested | Amy Ideozu |
| 3.2.1.4 | Video Stream quality | Stream quality of 480p | Video stream from camera is broadcasted to website using program where it can be monitored | Tested | Richard Taylor |
| 3.2.2.1 | Mass of IPT | Mass of maximum 213 grams | Measure system of sensors and actuators with a digital scale | Not Tested | Evan Lingo |
| 3.2.2.2 | Size | Volume should be 1.5 inches in height, 2 inches in width, 3 inches in length | Perform measurements for the enclosure created for the IPT | Not Tested | Evan Lingo |
| 3.2.3.1.1 | Power consumption | Max 3W consumption | Perform a power up to stable test | Tested | Evan Lingo |
| 3.2.3.2.2 | Output Voltage Level | Outout voltage level of 3.3V and 5V | Line regulation and load regulation test | Tested | Evan Lingo |
| 3.2.3.2.3 | Raw Video Output | Streams video to user via ip | The video stream will be available to watch whenever the user checks the designated web ip | Tested | Richard Taylor |
| 3.2.5.1.1 | GPS Functionality | GPS module provides accurate data tracking via program | The gps program will decode the NMEA sentences and provide gps coordinates of the current location of the module | Tested | Richard Taylor |

# IoT Based Pet Tracker

Amy Ideozu, Evan Lingo, Richard Taylor

# SUBSYSTEM VALIDATION REPORTS

REVISION – Draft
30 April 2022

# SUBSYSTEM VALIDATION REPORTS
FOR
# IoT Based Pet Tracker

APPROVED BY:

______________________________________
Project Leader Date

______________________________________
John Lusher II, P.E. Date

______________________________________
T/A Date

## Change Record

| Rev. | Date | Originator | Approvals | Description |
|---|---|---|---|---|
| - | 04/30/2022 | IoT Based Pet Tracker | | Draft Release |

# Table of Contents

# List of Figures / Tables

# 1. Introduction

The Internet of Things (IoT) Based Pet Tracker will provide GPS location and requested video feed as well as a variety of other features to enhance pet safety and monitoring. The design will be broken down into the sensors and actuators, microcontroller, and GUI subsystems. Each subsystem was designed and validated through multiple different tests, and with that we can see a direct path into integration to form one complete system. This document will discuss in detail what was done to design each subsystem as well as the different tests that were performed for validation.

# 2. Sensors and Actuators Subsystem Report

## 2.1. Subsystem Introduction

The sensors and actuators subsystem is the only hardware component of our design. This subsystem is designed to provide power, through the use of a lithium ion battery, to all of the components that will be placed onto the collar of the pet. The sensors and actuators subsystem was tested to verify that it will be able to provide power to the 6 different components of the system.

## 2.2. Subsystem Details

As mentioned above, the design will consist of two buck/boost converters that will be powered by a 3.7V lithium ion battery. One goes from 3.7V to 3.3V, and the other from 3.7V to 5V. These two circuits will provide power to all of the components in the design.

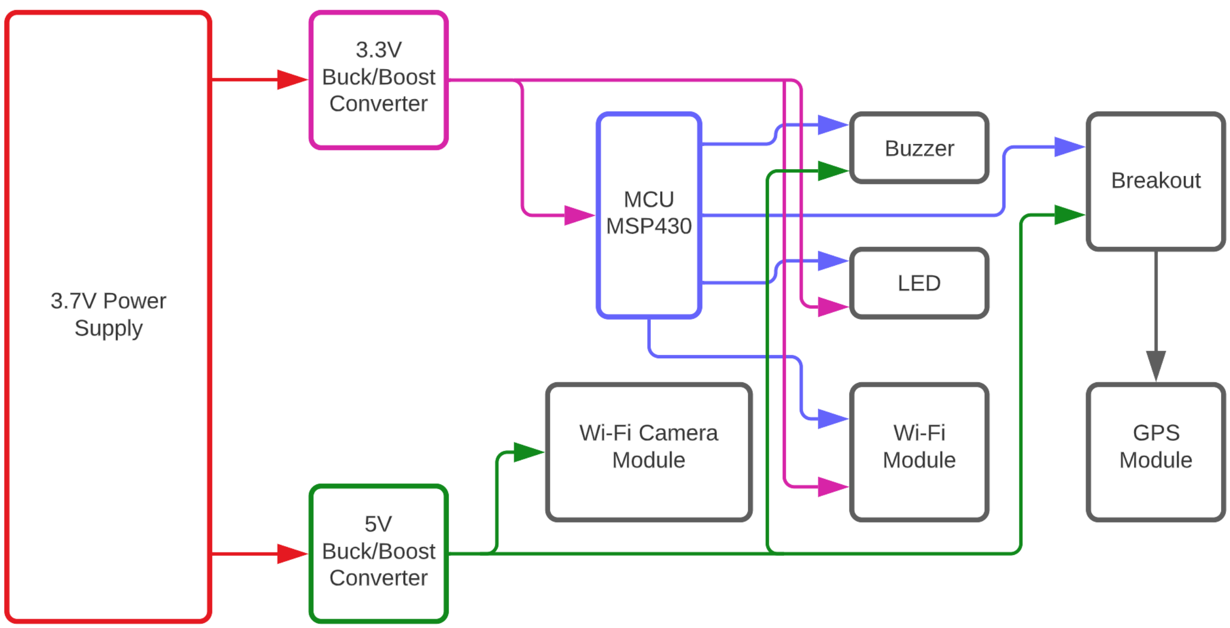


*Figure 1: Block diagram of sensors and actuators subsystem*

### 2.2.1. 3.7V to 3.3V Buck/Boost Converter

The first buck/boost converter that will be going from 3.7V to 3.3V will consist of 3 of the 6 components in the design. The microcontroller, Wi-Fi module and LED. Below is a table of the current consumption of each of the different components in this circuit.

| Component | Current Consumption |
|---|---|
| Microcontroller | 220µA |
| Wi-Fi Module | 60mA |
| LED | 20mA |

*Table 1:Current Consumption of the first buck/boost converter*

### 2.2.2. 3.7V to 5V Buck/Boost Converter

The second buck/boost converter that will be going from 3.7V to 3.3V will consist of the last 3 of the 6 components in the design. The GPS module, buzzer and Wi-Fi camera module. Below is a table of the current consumption of each of the different components in this circuit.

| Component | Current Consumption |
|---|---|
| GPS Module | 2mA |
| Buzzer | 25mA |
| Wi-Fi Camera Module | 180mA |

*Table 2:Current Consumption of the second buck/boost converter*

### 2.2.3. Microcontroller

There will be 4 components that will be connected to the microcontroller, which is the MSP430. These components are the GPS module, Wi-Fi module, LED and buzzer. The Wi-Fi module will provide the microcontroller with the ability to connect to our database so that the GPS module can transmit its location to the user on the app. The LED and buzzer will be activated whenever the pet is outside of the allowed safe area defined by the user.

### 2.2.4. LED and Buzzer

Upon exiting the allowed safe area defined by the user, the LED and buzzer will be activated. This means that the LED will begin blinking and the buzzer will similarly begin turning on and off. This is to help you find your pet whenever you are getting close while following its GPS location.

### 2.2.5. Wi-Fi Module

Because the microcontroller cannot connect to the database on its own we have a Wi-Fi module to help it do that job. We are using the ESP8266.

### 2.2.6. Wi-Fi Camera Module

Once the user has requested video feed from the app the Wi-Fi camera module will be activated. If the user is not requesting video feed then the camera will remain off. The device that we are using to complete this is an ESP32. This will allow us to connect the camera directly to the database.

#### 2.2.7. GPS Module

Connect to the microcontroller, the GPS module will be transmitting its location to the database to be sent to the user. The device that we are using is the EM-506.

## *2.3. Subsystem Validation*

For validation I constructed both of the buck/boost converter circuits onto a perfboard. This allowed me to test the power consumption as well as the output voltage levels of the two circuits. Below are images of the perfboard as well as the buck/boost converter (LTC3441) connected to it.

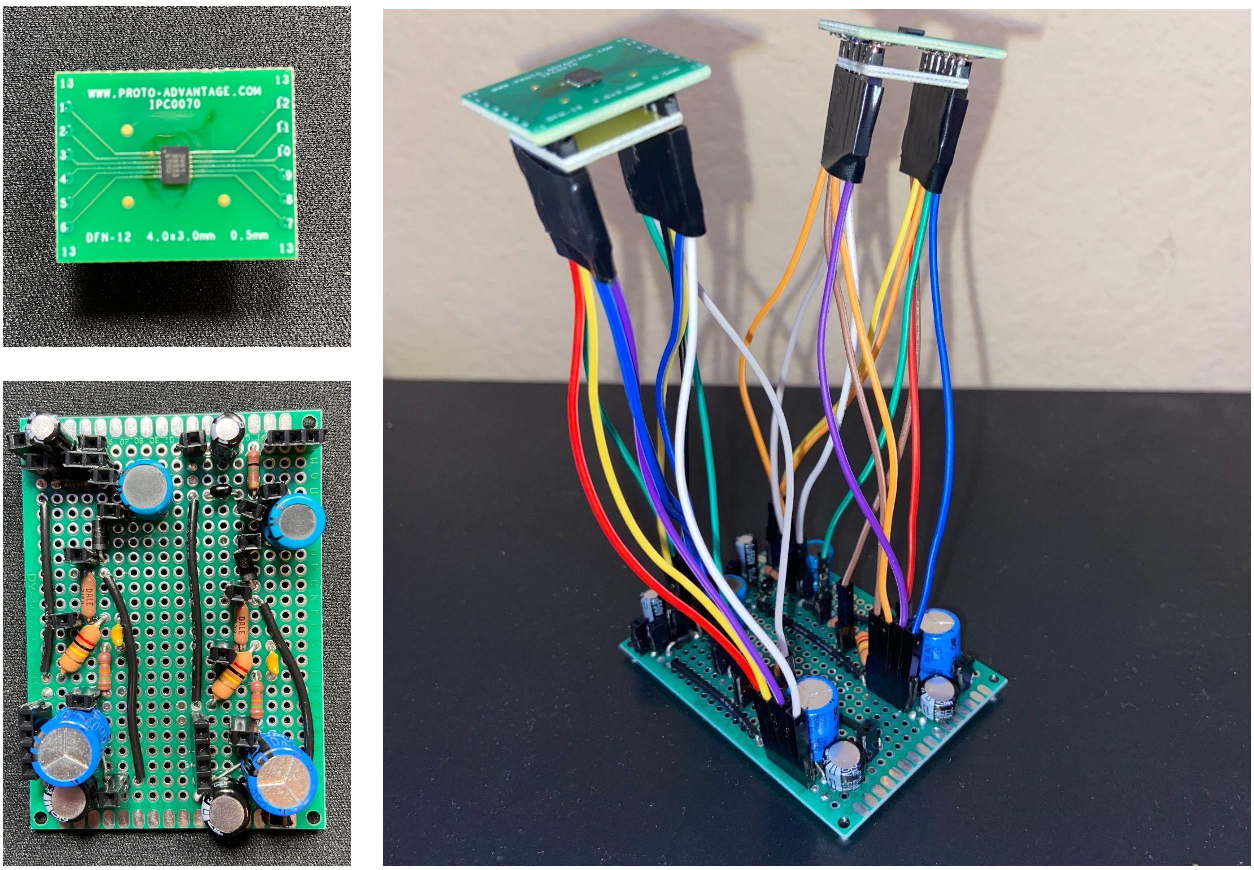


*Figure 2: Images of finalized perfboard*

### 2.3.1. Battery Operating Life

Testing for the battery operating life will come in 404 whenever the whole design is connected together, but we can take a look at the current consumption of all of the components as well as the total amp hours on our battery. With 4400Ah and a total current consumption of 287.22mA we are looking at around 15.3 hours of battery life, which exceeds the goal of around 8 hours.

### 2.3.2. Mass of IPT

Measurements of the total mass of the system will come in 404 once the design is put together and a housing unit is made for the whole system to be placed in. This is the housing unit that will be attached to the collar of the pet.

### 2.3.3. Size

Similarly, to the mass of the IPT, the size of the IPT cannot be measured until 404 because the housing unit for the system is not constructed yet.

### 2.3.4. Power Consumption

For the first buck/boost converter going from 3.7V to 3.3V, there was a current of 0.5A that was required to power the circuit. With a supply of 3.7V and 0.5A needed, that is a power consumption of 1.85W. For the second buck/boost converter going from 3.7V to 5V, there was a current of 0.5A that was required to power the circuit. With a supply of 3.7V and 0.8A needed, that is a power consumption of 2.96W.

### 2.3.5. Output Voltage Level

To test the output voltage level, I provided each buck/boost converter with 3.7V and the required amperage needed to power the circuit and measured what the output voltage was and looked at the noise of the circuit. For the first buck/boost converter going from 3.7V to 3.3V I received an output voltage of 3.096V with an output waveform of the one below.

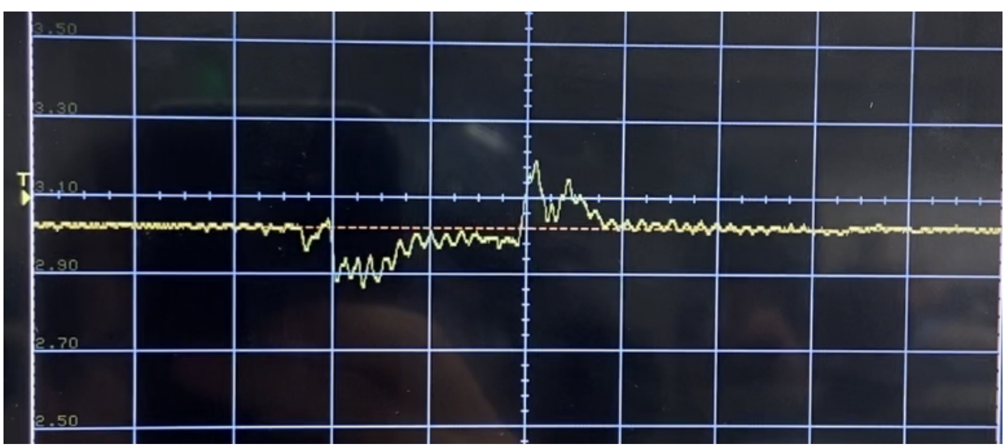


*Figure 3: Output waveform from first buck/boost converter*

For the second buck/boost converter going from 3.7V to 5V I received an output voltage of 4.918V with an output waveform of the one below.

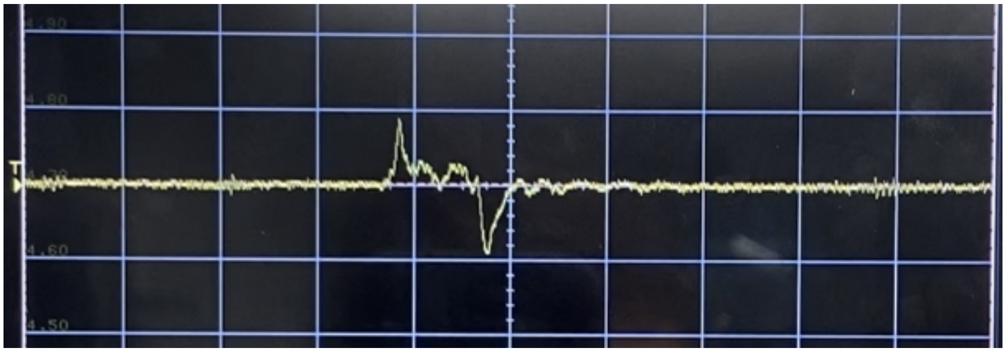

*Figure 4: Output waveform from first buck/boost converter*

My first buck/boost converter produced an output voltage of about 0.3V less than what is desired with a lot more noise than what is wanted. This is due to the fact that some of my parts are not rated to the correct specifications and will have to be switched out. Also, the noise will be reduced whenever the final design is on a PCB due to the fact that there will be no long jumper wires on the circuit. The second buck/boost converter produced about 0.1V less than the desired output, but as mentioned before some parts are not rated correctly. The noise however is significantly less than the first circuit and will continue to decrease as it is moved to a PCB.

## *2.4. Subsystem Conclusion*

The sensors and actuators subsystem was shown to work as expected with a few minor flaws that will be fixed moving forward. The system will be able to effectively provide the needed power for each component in the system. Looking forward into the future, there will be a design and fabrication of a PCB with all of the components integrated into the circuit. As well as a housing unit being made to hold this PCB and the power supply securely. This unit will also be attached to a collar for a pet.

# 3. Microcontroller Subsystem Report

## *3.1. Subsystem Introduction*

The Microcontroller subsystem is the series of programs that will use the microcontroller to provide GPS data and camera data to the user via the database for the IPT. There will also be programs to activate the led and buzzer when the pet exits the designated safe zone.

## *3.2. Subsystem Details*

The Subsystem is currently made of an EM 506 GPS module setup on a breadboard hooked up to a computer through a GPS breakout and UART connector. The ESP32 Camera is a camera that can be programmed through the computer via a USB to microUSB cable and then removed and placed on the IPT. In the future, the microcontroller will be connected to the GPS, LED, and Buzzer, with the camera acting separately.

### 3.2.1. GPS Program

I created the GPS program to decode the NMEA sentences that input from the EM 506 GPS module and send the related information to the internet database so the user of the app can see the location.

### 3.2.2. Camera Program

Unlike all other aspects of this project, the Camera program does not function related to GPS. Instead, the user can request a video feed from the android app using the local IP generated from the camera program which shows the camera feed.

### 3.2.3. Buzzer and LED Program

The Buzzer and LED program will function based on the safe zone GPS information sent from the Android app via the database. It will activate the buzzer and LED as soon as the pet has exited the safe zone so the user will be able to have an auditory and visual indicator that the pet is not in the safe zone

## *3.3. Subsystem Validation*

### 3.3.1. GPS Program Validation

The GPS program works successfully and decodes GPS data into a form that can be used by google maps to then check the exact coordinates of the module itself.

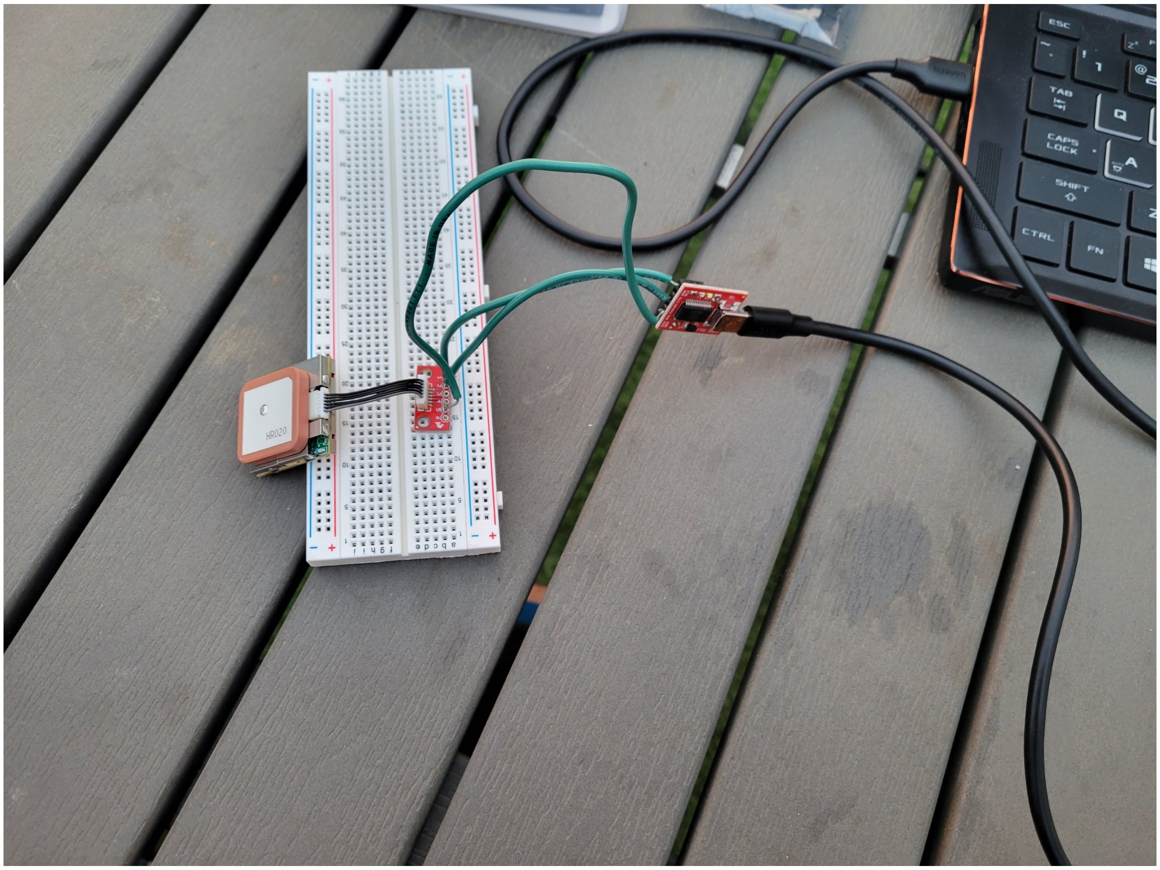

*Figure 5: EM 506 to computer testing system*

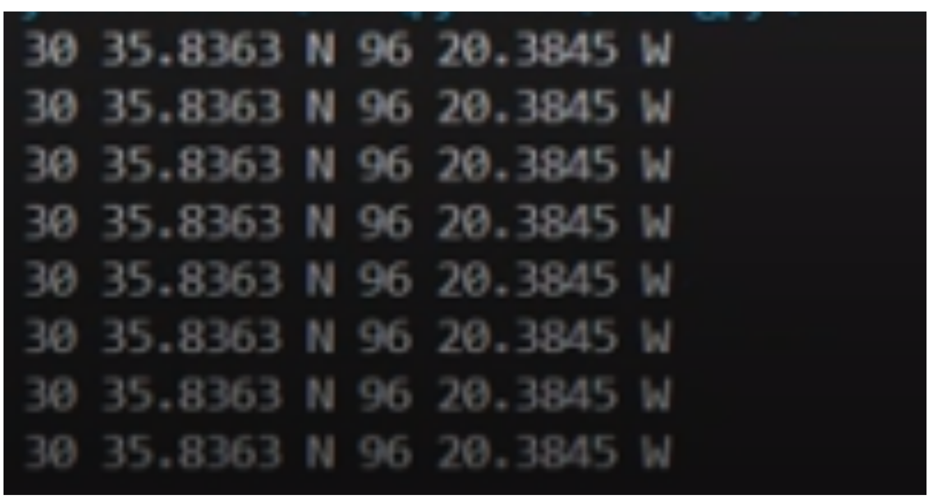


*Figure 6: Coordinate output of GPS program*

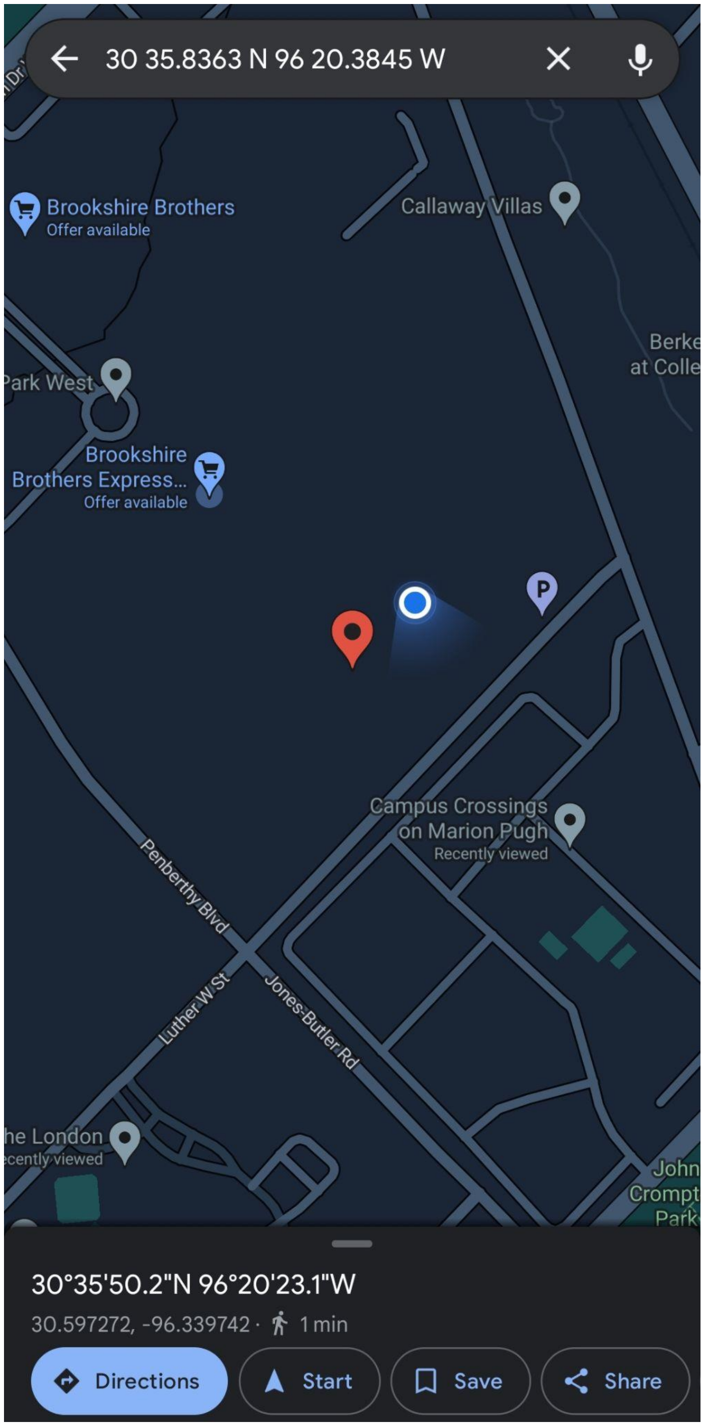


*Figure 7: Location displayed on google maps via GPS coordinates*

### 3.3.2. Camera Program Validation

The Camera Program works successfully and provides a local IP in which the user can view the camera feed. The Camera can also be disconnected from the computer and provided power and still provide a video feed when it is done being programmed.

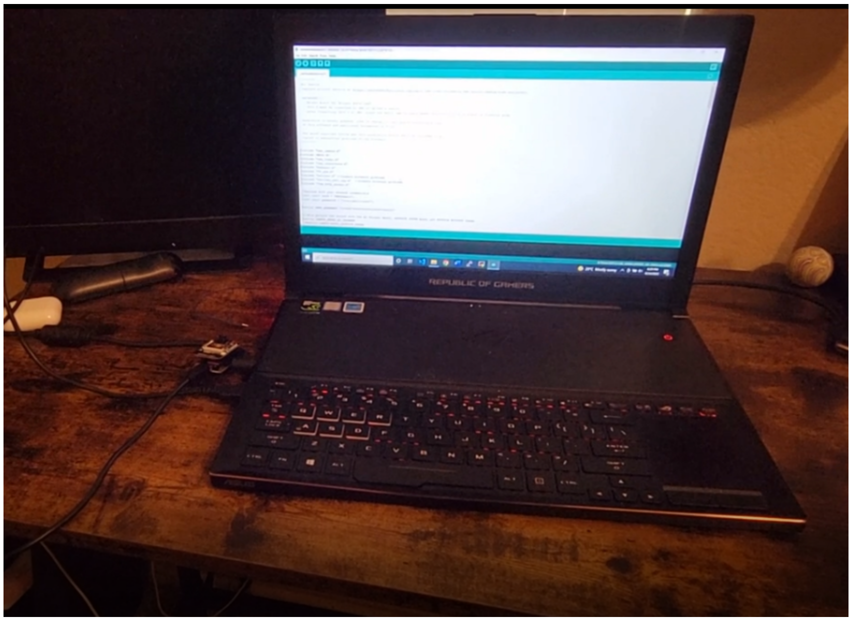


*Figure 8: ESP32 CAM programming setup*

*Figure 9: Example Screenshot of Camera feed from ESP 32 CAM*

*Figure 10: ESP32 Camera setup without Computer*

#### 3.3.3. Buzzer and LED Program Validation

In 403, the subsystems are not connected so there is no safe data for me to use to activate the LED and Buzzer. However, a program of this should be very simple to create and implement in 404.

### *3.4. Subsystem Conclusion*

The Microcontroller program works well with some issues that will need to be fixed going forward. These issues include needing to implement a static IP for the Camera program as well as implementing the GPS with the microcontroller. The LED and Buzzer programs will need to be created and implemented with a microcontroller as well. Other than these issues, the subsystem is functioning as expected. Implementing these factors as well as combining all subsystems together will prove valuable to the IPT in 404.

# 4. Android Application (GUI) Report

## *4.1. Subsystem Introduction*

The GUI is contained in the form of an Android application and allows the user to add the pet(s) they wish to be monitored and designate “safe areas” for their pet(s). User account information is stored in a Firebase Authentication database, whereas the information for the user’s pet(s) and defined safe areas, as well as the tracker information, are stored in a Firebase Realtime database.

## *4.2. Subsystem Details*

### 4.2.1. Account Creation

When first opening the application or opening the application again after logging out of an account, the user will be taken to the launch page where they will be given the option to register a new account or log in with a preexisting account. If the user chooses to register a new account, they will be navigated to the login page upon entering a valid email address and a proper password—a password that is at least 8 characters and contains at least one uppercase, one number, and one valid special character (!@#$%&+=). The user account is added to the Authentication database when successfully created. From the login page, once the user enters the correct credentials, they will be taken to the landing page where they can view their pet(s) or add a pet.

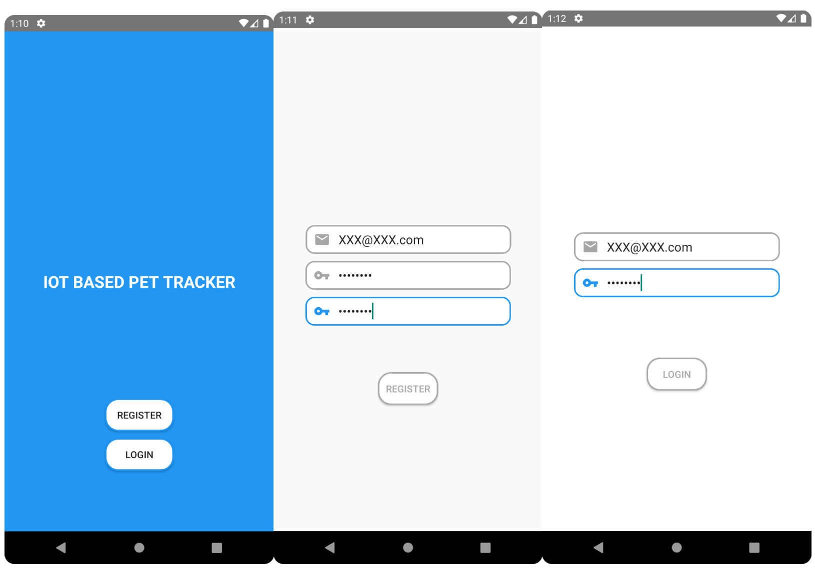


*Figure 11: The Launch, Register, and Login pages*

### 4.2.2. Pet Creation

On the landing page titled “Pets”, the user will be presented with a screen that lists the pets they have currently added to be tracked, if any. The option for the user to add a new pet will always be present near the bottom of the screen. Upon selecting the option to add a pet, the user will be redirected to a pet creation page, where they will be prompted to enter their pet’s name, the tracker identification number, and the camera IP address. After entering valid information and confirming the pet creation, the pet will be added to the Realtime database and added to the list on the landing page.

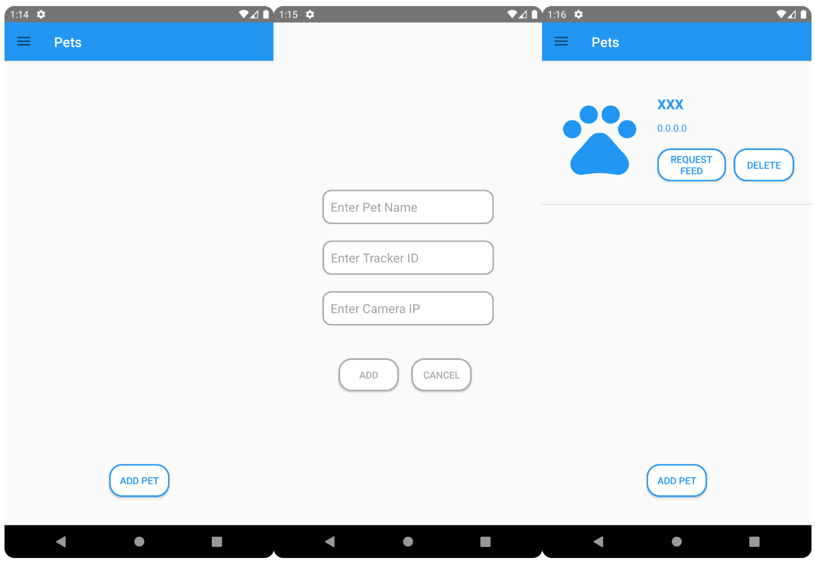


*Figure 12: Landing/Pets (No Pets), Add Pet, and Landing/Pets (One Pet) pages*

Additionally, back button navigation has been disabled on this page. By swiping right on the left corner of the screen or tapping the action bar in the upper left corner, the user will be able to navigate to different pages of the app.

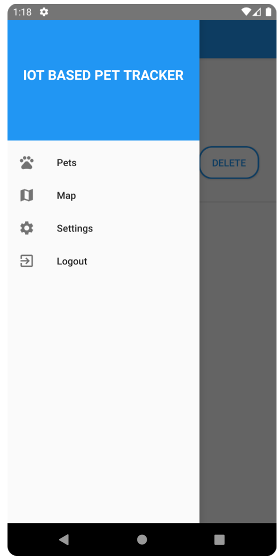


*Figure 13: The Navigation Drawer*

### 4.2.3. Track Pet/Add Safe Area

If location permissions have not been granted, the user will be prompted to enable them when navigating to the "Maps" page. Once the permissions are granted, the user will be able to see their current location, as well as the location of their pet(s) and their safe areas if they have been added.

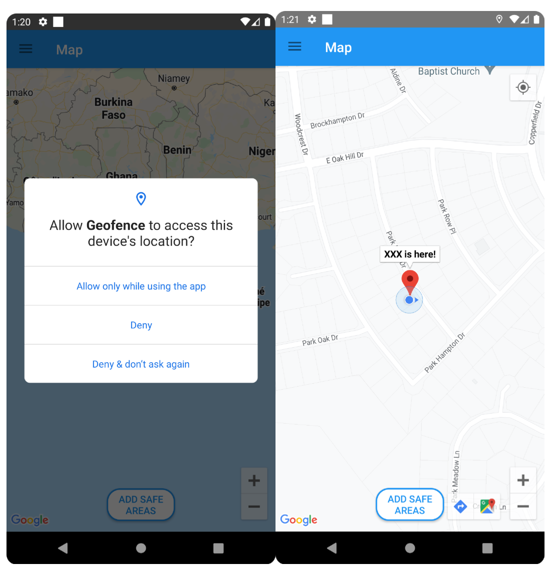


*Figure 14: Asking for permission, user and pet location shown*

Near the bottom of the screen, the option to add additional safe areas will be presented. If the user chooses to select this option, they will enable “Safe Area Creation Mode.” While in this mode, the user can long tap to place four markers on the map to surround an area. Once the fourth pin is placed, a polygon will be drawn on the map, to which the user will have the option to confirm or delete. If confirmed, the confirmed polygon will become a geofence or “safe area,” added to the database, and will be monitored for pet activity.

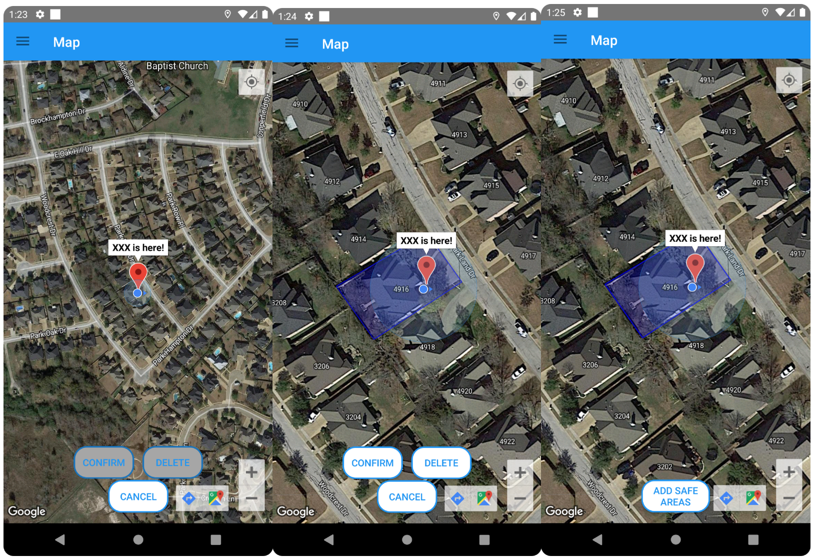


*Figure 15: Safe Area Creation mode, creating a safe area, safe area added to map*

Additionally, back button navigation has been disabled on this page. By swiping right on the left corner of the screen or tapping the action bar in the upper left corner, the user will be able to navigate to different pages of the app.

### 4.2.4. Notification System

After adding a safe area, the application will begin to track pet movement within the enclosed location. When a pet or pets leave a safe area, a notification will be sent to the user, regardless of whether the user is active on the app or not. Only one notification will be sent out; right when the pet leaves the safe area.

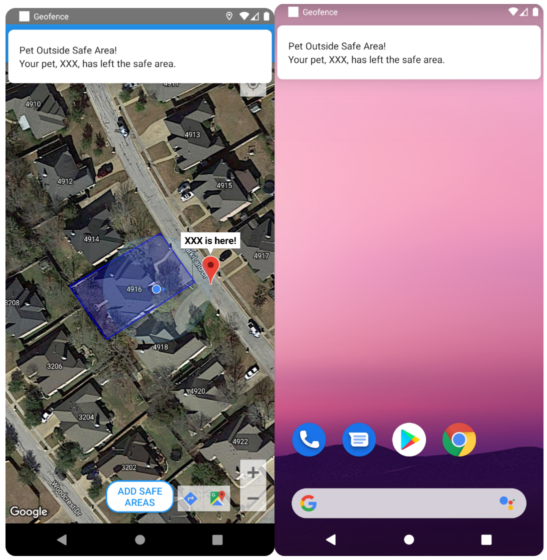


*Figure 16: Notification in app, notification with app in background*

### 4.2.5. Log Out

After the user logs in, the app will take them straight to the landing page, or "Pets" page, every time they open the app unless they log out. To log out, the user will have to navigate to the logout page and press the logout button. After logging out, the user will be redirected to the launching page the app will continue to open the launching page until the user signs in again.

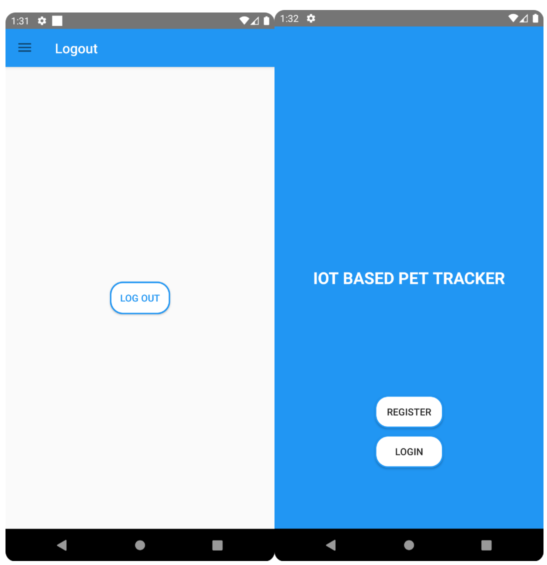


*Figure 17: After logging out, user is taken back to Launch page*

Additionally, back button navigation has been disabled on this page. By swiping right on the left corner of the screen or tapping the action bar in the upper left corner, the user will be able to navigate to different pages of the app.

## 4.3. Subsystem Validation

### 4.3.1. Safe Area Size

In order to be feasible, a safe area must encompass an area that is at least 100 sq ft. Similarly, the area mustn't be too large either—at most 36,000 sq ft, which is approximately an eighth of an acre. To prevent users from going outside this range, safe areas will automatically be deleted if they are made less than 100 sq ft or more than 36,000 sq ft.

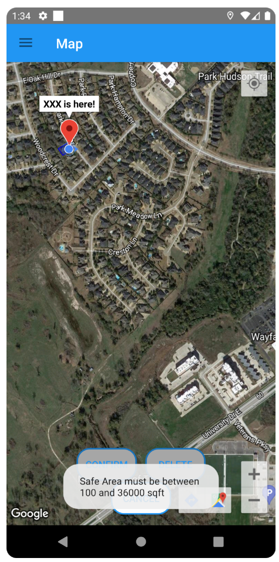


*Figure 18: User tries to make a safe area >36,000 sq ft*

### 4.3.2. Time to Alert

Ideally, a pet owner should be notified as soon as possible when their pet leaves their safe area. To enable the user to act quickly, they should be notified within the minute their pet leaves the safe area. By using Firebase's Realtime database, the time in between the pet leaving the user defined area and the user's notification can be <1 second with excellent Wi-Fi connection.

## *4.4. Subsystem Conclusion*

This GUI subsystem was shown to successfully allow users to monitor the pets they wish. By using the Firebase Authentication and Realtime databases, users can create an account, log in and log out, add and/or view their added pets, monitor their pet's location, create reasonably sized safe areas to be monitored, and get notifications when their pet is outside of a safe area in a timely manner. In the future, this subsystem will be expanded to allow the user to request a video feed from their pet and will also include additional quality of life features to improve the user experience.