**System Requirements Specification**

**Radio Frequency (RF) Direction of Arrival**

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**Section 1: Introduction**

**1.1 System to be produced.**

This product will allow the user to track an illegal drone operating in the 33cm RF band that extends from 902 to 928MHz, the system will display the antenna gain relative to an ideal isotropic antenna and the angle at which the antenna picks up the strongest frequency of the drone. For development testing purposes, this system will simulate the drone using 915MHz telemetry radios. The system will track the simulated drone using a rotating Yagi antenna.

**1.2 Applicable Standards**

The system will adhere to the following standards:

* IEEE Standard 149: Standard Test Procedures for Antennas
* Radio Regulations of the International Telecommunication Union: Amateur Redio Operation Frequency

**1.3 Definitions, Acronyms, and Abbreviations**

DOA -Direction of Arrival

EECSE - Electrical Engineering and Computer Science

FAA - Federal Aviation Administration

MHz - Mega Hertz

NFM - Narrow-band FM

RF- Radio Frequency

SDR - Software Defined Radio

WFM - Wide-band FM

FHSS – Frequency Hopping Spread Spectrum

**Section 2: Product Overview**

**2.1 Assumptions**

The following assumptions apply to our system:

* This system deals with a FHSS signal radiating from the telemetry radios.
* The FHSS signals will hop within the 33cm RF band (902-928MHz)
* The detected signal hops instantaneously across the frequency band.
* The point where the antenna gain is the highest represents the DOA of the simulated drone.
* The point here the antenna gain is the lowest represents a ±90° deviation from DOA.
* The characteristic impedance of the system is 50Ω.

**2.2 Stakeholders**

Customer: Wants to detect where drones are coming from.

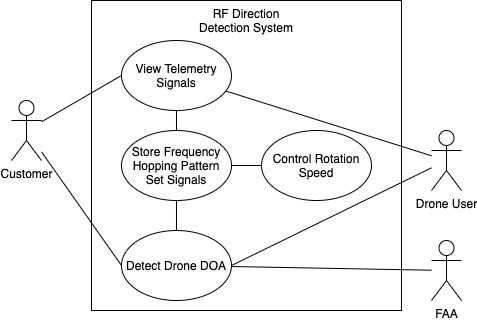
FAA: Wants to detect illegally flying drones within restricted airspace (i.e. airports, military base, etc.)

Drone User: Wants to find lost drones or keep track of drones from far away.

**2.3 Event Table**

|  |  |  |  |
| --- | --- | --- | --- |
| Event Name | External Stimuli | External Responses | Internal data and state |
| No Signal | No drone in airspace | Antenna will receive no signal at all angles. | SDR software discards data until signal appears. |
| Drone flying overhead. | Drone communication in the 33cm RF band. | Antenna receives communication signal from 33cm RF band. | SDR processes the signal data and displays the strength of the signal at the given frequency. |
| Frequency Hopping | Carrier frequency of signal hops into different frequencies. | SDR software registers all signals from the frequency hopping pattern before changing angles. | SDR registers each set of frequency hopping patterns and their correlating antenna angle. |
| Antenna pointed in the DOA | The drone is parallel to the plane of the Yagi antenna. | The measured antenna gain is the highest. | SDR registers this frequency hopping set and angle as the DOA. |
| Antenna pointed ±90° from DOA. | The drone is perpendicular to the plane of the Yagi antenna. | The measured antenna gain is at its lowest. | SDR registers this frequency hopping set and angel as ±90° away from the DOA. |

**2.4 Use Case Diagram**



**2.5 Use Case Descriptions**

* FAA - Will use the system’s location database to detect drones in illegal airspace.
* Drone Users - Will fly their drone that is communicating with the system. They may use the system’s location database to find lost drones or detect drones from far away.
* Customer - Will set up Yagi antenna and SDR software to view telemetry signals and detect the drones DOA.

**Section 3: Specific Requirements**

**3.1 Functional Requirements**

* **3.1.1 Antenna**
  + 3.1.1.1 The Antenna shall be able to rotate at least 180 degrees and detect RF signals operating between 902-928MHz
  + 3.1.1.2 The user shall be able to connect the telemetry radios to each other using Mission planner.
  + 3.1.1.3 The Airspy software shall display the spectrum of the data exchanged between the Pixhawk, GPS and telemetry radios.
* **3.1.2 Stepper motor**
  + 3.1.2.1 The stepping motor shall be able to rotate at least 180 degrees clockwise.
  + 3.1.2.2 The stepping motor shall be able to rotate at least 180 degrees counterclockwise.
  + 3.1.2.3 The stepping motor shall be able to rotate at any numerical speed the user inputs.
  + 3.1.2.4 The stepping motor shall be able to stop when the end stop switch is pressed and held.
  + 3.1.2.5 The stepping motor shall be able to rotate the attached antenna.

**3.2 Interface Requirements**

* **3.2.1 User Interfaces**
  + 3.2.1.1 The user shall be able to connect the Pixhawk interface to Mission Planner via a connection though the computer’s USB ports.
  + 3.2.1.2 The user shall be able to specify the types of connection for the Pixhawk device in Mission Planner.
  + 3.2.1.3 The user shall be able to simulate a GPS-based flight path in Mission Planner.
  + 3.2.1.4 The user shall interface with Arduino to be able to control the rotation and direction of the stepping motor. The user shall change the following lines of code:
    - 3.2.1.4.1 Rotation (Line 12): This line controls the degrees the stepping motor turns in any direction.
    - 3.2.1.4.2 Speed (Line 13): This line controls the speed at which the stepping turn by adding a delay between each pause.
  + 3.2.1.5 The user shall use software Airspy to visualize the spectrum of data transferred at the selected frequency.
  + 3.2.1.6 The user shall use Simulink to convert the visualized data received by the SDR to magnitudes and phase angles.
    - 3.2.1.6.1 The highest printed magnitude gain shall represent the frequency and angle at which the signal is received.
* **3.2.2 Hardware Interfaces**
  + 3.2.2.1 The drone platform shall consist of the Pixhawk telemetry module and a GPS module.
  + 3.2.2.2 The system shall operate as followed:
    - 3.2.2.2.1 The Pixhawk shall simulate the flight pattern of a drone.
    - 3.2.2.2.2 Mission Planner shall track the Pixhawk’s location and flight parameters using the GPS.
    - 3.2.2.2.3 The telemetry radios shall establish connections and data transfers between the Pixhawk, laptop and Mission planner.
  + 3.2.2.3 The testing hardware shall be coordinated by a single-board computer.
  + 3.2.2.4 The testing hardware shall consist of the following:
    - 3.2.2.4.1 Software defined radio
    - 3.2.2.4.2 GPS module
  + 3.2.2.5 The base station shall consist of a laptop running Mission Planner, Airspy and Arduino.
  + 3.2.2.6 The base station shall consist of a stepping motor with a Yagi antenna design attached to the stepping motor.
  + 3.2.2.7 The Yagi antenna shall constantly be rotating 180/360 degrees through the stepping motor which is powered by Arduino.
  + 3.2.2.8 The stepping motor shall consist of the following:
    - 3.2.2.8.1 CNC Shield Board
    - 3.2.2.8.2 Arduino Uno Board
    - 3.2.2.8.3 1.5m USB cable for Board
    - 3.2.2.8.4 Nema 17 Stepper Motor 1.7A
    - 3.2.2.8.5 Mechanical Switch Endstop
    - 3.2.2.8.6 3 pin 70cm cable
    - 3.2.2.8.7 DRV8825 Stepper Motor Driver
    - 3.2.2.8.8 Aluminum heatsink
    - 3.2.2.8.9 12-volt battery supply
  + 3.2.2.9 The antenna shall consist of the following:
    - 3.2.2.9.1 The antenna shall operate in the 902-928 MHz range
    - 3.2.2.9.2 The antenna shall have a peak gain at 915 MHz
* **3.2.3 Software Interfaces**
  + 3.2.3.1 The operating software shall be able to process communication between all components.
  + 3.2.3.2 The system shall use the software Arduino to be able to run the stepping motor.
  + 3.2.3.3 The system shall use the software Airspy to be able to read and display the signal received by the Yagi antenna.
  + 3.2.3.4 The system shall use the software Mission Planner to be able to read and display the Pixhawk drone simulation.
  + 3.2.3.5 The system shall use Simulink to convert and print out complex data generated by the RTL-SDR to magnitude gain and phase angle.
* **3.2.4 Communications Interfaces**
  + 3.2.4.1 The system shall be able to detect signals operating in the 33cm RF band.
  + 3.2.4.2 The system shall observe a minimal signal gain when the source is located in perpendicular to the antenna.
  + 3.2.4.3 The system shall observe a maximum signal gain when the source is located in parallel to the plane of the antenna.

**3.3 Physical Environment Requirements**

* + 3.3.1 The system must operate outside.
  + 3.3.2 The system must be able to operate in heat and humidity levels typical to central Florida.

**3.4 User and Human Factors Requirements**

* **3.4.1 User Requirements**
  + 3.4.1.1 The user shall have basic knowledge of telecommunications.
  + 3.4.1.2 The user shall have the technical knowledge required to set up the system.

**3.5 Documentation Requirements**

* + 3.5.1 The documentation shall be in either PDF or .docx format.

**3.6 Data Requirements**

* + There are no requirements for this section.

**3.7 Resource Requirements**

* 3.7.1 The system shall require at least one person with sufficient knowledge to setup and operate the system.
* 3.7.2 The system shall require a source of power.

**3.8 Security Requirements**

* + There are no requirements for this section.

**3.9 Quality Assurance Requirements**

* + There are no requirements for this section.

**Section 4: Supporting Material**

* The above requirements were defined by utilizing information provided by the product owner and involved stakeholders over the course of the project.