Conceptual Design and Planning Draft

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I. INTRODUCTION

Unmanned aircraft systems, colloquially referred to as drones, have been integrated into society over the course of the past decade. Paired with their integration were a slew of safety concerns, which, until recently, have had very few practical solutions. In September 2023, the Federal Aviation Administration (FAA) issued a new requirement stating that registered drones above a certain weight must emit an identification signal, dubbed "Remote ID". This signal constantly transmits valuable information about the drone such as the serial number of the drone, the current geological latitude and longitude of both the drone and the controller, the current altitude of both the drone and the controller, the current velocity of the drone, an emergency status, and a time stamp [1].

A. The Formulated Problem

Given the preceding information, our team has been tasked with creating an electronic sensing system to detect drones that both enter the Tennessee Technological University (TTU) airspace and emit the Remote ID signal. Once detected, the information about the drone will be relayed to the TTU police department so they can assess the threat to campus security and take whatever action they deem necessary. The system will be constrained with regards to ethical engineering decisions, existing standards for operation, potential broader impacts, and specifications relayed to us by our customer and advisor. These constraints are as follows:

1) The system shall detect and track remote ID emitting drones for the contiguous Tennessee Technological University campus.
   - The contiguous university covers a total area of approximately 267 acres or 11,630,000 square feet.
2) The system shall record and store all data recovered from the Remote ID signal.
3) The system shall notify campus police in real-time upon detection of a drone in flight.
   - "Real-time" is constrained by the networking and hardware capabilities.
4) The data shall be displayed in real-time upon detection of a drone in flight.
5) The system shall allow campus police to authorize drones for permitted flights in a specified time frame.
   - This constraint was requested by the TTU police as there are certain drones that are permitted to fly on campus. The police do not want to receive an alert for a permissible drone.
6) The system shall increase the alert's urgency if a drone is detected in a private geological region.
   - The private geological regions will be defined by the TTU police.

II. ETHICAL, PROFESSIONAL, AND STANDARD CONSIDERATION

A. Ethical

Along with the constraints placed on the system by stakeholders in this project, the team must take into account the ethical concerns of creating the drone tracking system.

One such concern that the team must address is the willingness of the campus community to be tracked to such a degree. TTU Policy 190 (Unmanned Aircraft Systems) dictates that to operate a drone on TTU property, a user must comply with any local, state, and federal policies and standards [2]. In line with this, according to Part 107 of Title 14 of the Code of Federal Regulations, one specific rule is as follows: "Do not fly a drone over people unless they are directly participating in the operation" [3]. Neither local nor Tennessee state laws offer any extra stipulations to this rule, so it is plausible to say that flying a drone on a college campus inherently breaks this rule. While legally these drones are in fact breaking a law, is it truly necessary to enforce it at all times? How would enforcement of this rule reflect back on the university? In the current digital landscape, people have a hard time believing that they are not under constant observation.

This brings us to an ethical dilemma where we likely will leave the ultimate decision up to TTU police. In reality, they are likely not going to go out and examine each drone that shows up on the sensor. Doing so would impose a negative perception of campus culture, which is something the university would strive to avoid. The purpose of our system is to legitimize the idea that, if a drone is found to be in severe violation of the law, the campus police have the capabilities to take care of the problem.

B. Standards

The drone tracking system will emit and receive signals in ranges between 2 and 5 GHz. This will require us to adhere

to FCC Policy 47 CFR § 15, limiting the power and exposure levels to safe levels [4]. For receiving data from drones, we will be utilizing the elements required to be transmitted by Remote ID drones as stated in FAA Policy 14 CFR § 89.305 and 14 CFR § 89.315 [5].

With regards to data transmission and storage, we will build our network architecture to uphold the transmission standards of IEEE 802.11 and the protection standards of TTU Policies 403 and 856. The IEEE standard is the basis for all Wi-Fi communications worldwide, and specifies which bands of frequency are able to be used for which purpose. TTU policies 403 and 856 defines standards for surveillance camera usage on campus and data protections standards respectively [6–8].

C. Broader Impacts

A drone tracking system for campus police will have both positive and negative impacts for the people involved. It is important for us to consider what effects our system will have on the people using it and the people that will be subject to its use.

Tech police will be positively impacted by the use of this system because they will be able to help keep the tech campus safer. Being able to identify where the control station is to stop the pilot from endangering bystanders will help suppress unsafe drone practices. Bystanders can be rest assured knowing that campus police will have a quicker more efficient means of stopping the drone before it can recklessly harm them or others. Dorms will also have a stronger level of protection from people trying to spy on them. The perpetrator of flying a drone to spy on dorm rooms will be much easier to find and be handled appropriately. This will improve privacy of Tech.

However, there are negative impacts that need to be considered as well. Tech could be viewed as overstepping their boundaries as an authority figure. To outsiders looking in or the drone pilots, a figure of power doing more to regulate and gather information about people may be too much. The main concern of negative impacts is the perception of the system. There may be a perception issue that TTU may be too controlling on the front of their campus. The university would also accumulate data on people that aren't students, and this could be seen as an invasion of privacy for many. The system being used on a state public university could be cause for concern across the state as the question would arise when state wide drone tracking may be employed.

III. Block Diagram

The full block diagram is shown in Fig.1 near the end of the document. The detailed explanations of the subsystems are as follows.

A. Power

The power system will be split into two parts. One will power the sensing system, while the other will power the camera system. Since the two systems will likely be installed at different locations, they will need to be powered separately.

1) Sensor Power: The power for the sensor system will most likely have access to an outlet, so the AC voltage will need to be transformed and converted to the desired voltage for the sensor system.
   - Input- 120 V 60 Hz Power
   - Output- Desired voltage for the sensor
2) Camera Power: The power for the camera system may not be able to rely on power to be transformed from a wall outlet, so we will need to use a battery and a voltage regulation to get the desired power for the system.
   - Input- Battery
   - Output- Desired voltage for the camera

B. Sensor

The sensor system will be responsible for receiving Remote ID (RID) data and unpacking it to be sent by the network to the website.

1) Antenna and GNU Radio:
   - Input- Signal
   - Output- RID Signal
2) Microprocessor
   - Input- RID Signal
   - Output- Packaged RID Signal
3) Storage Drive
   - Input- Packaged RID Signal
   - Output-

C. Network

The network system will receive the packaged data from the sensor and the camera. Then, the system will unpack the data using RID protocol and file transfer protocol before sending the information to the cloud server using 2.4 GHz WiFi

1) RID protocol
   - Input- Packaged data from Sensor.
   - Output- Drone ID, drone location and altitude, velocity, control station location and elevation, time mark, and emergency status.
2) File transfer protocol
   - Input- Packaged data from Camera.
   - Output- Image.

D. Camera

This subsystem will be responsible for tracking and capturing both the drone mid-flight and, in optimal cases, the drone pilot when they are within camera range. This is important for documentation purposes, and will greatly assist campus police in the event of a repeat offender. The hardware will pertain to the motor-camera assembly, while software will pertain to the micro-controller and code to drive the system.

1) Hardware
   - Input- Power, Software Data
   - Output- Motor Control Signal(s)
2) Software
   - Input- Drone and pilot position, altitude, velocity.
   - Output- Clean image/video of drone and/or pilot.

E. Website

The website subsystem will take in data from the database along with input from the user connected to determine what output will be returned to the user. It will allow the user to view the flight path of the drone across campus and, if captured, images of the drone in flight and/or the drone user.

- Input- Raw data from database and user-selected inputs
- Output- Organized data presented in a concise, usable manner.

IV. TIMELINE

The timeline is shown as a gantt chart in Fig.2 below. It follows the outline of the block diagram, showing more specified tasks and their time constraints than the previous gantt charts.

V. CONCLUSION

The conceptual design of our Drone Tracking System contains five central systems, with six total subsystems. The subsystems include the power system, the sensing and decoding system, the network, the camera-tracking system containing both hardware and software designs, and the website. This document will serve as an outline for the team's design moving forward, but does not list specifics required for a working system.

REFERENCES

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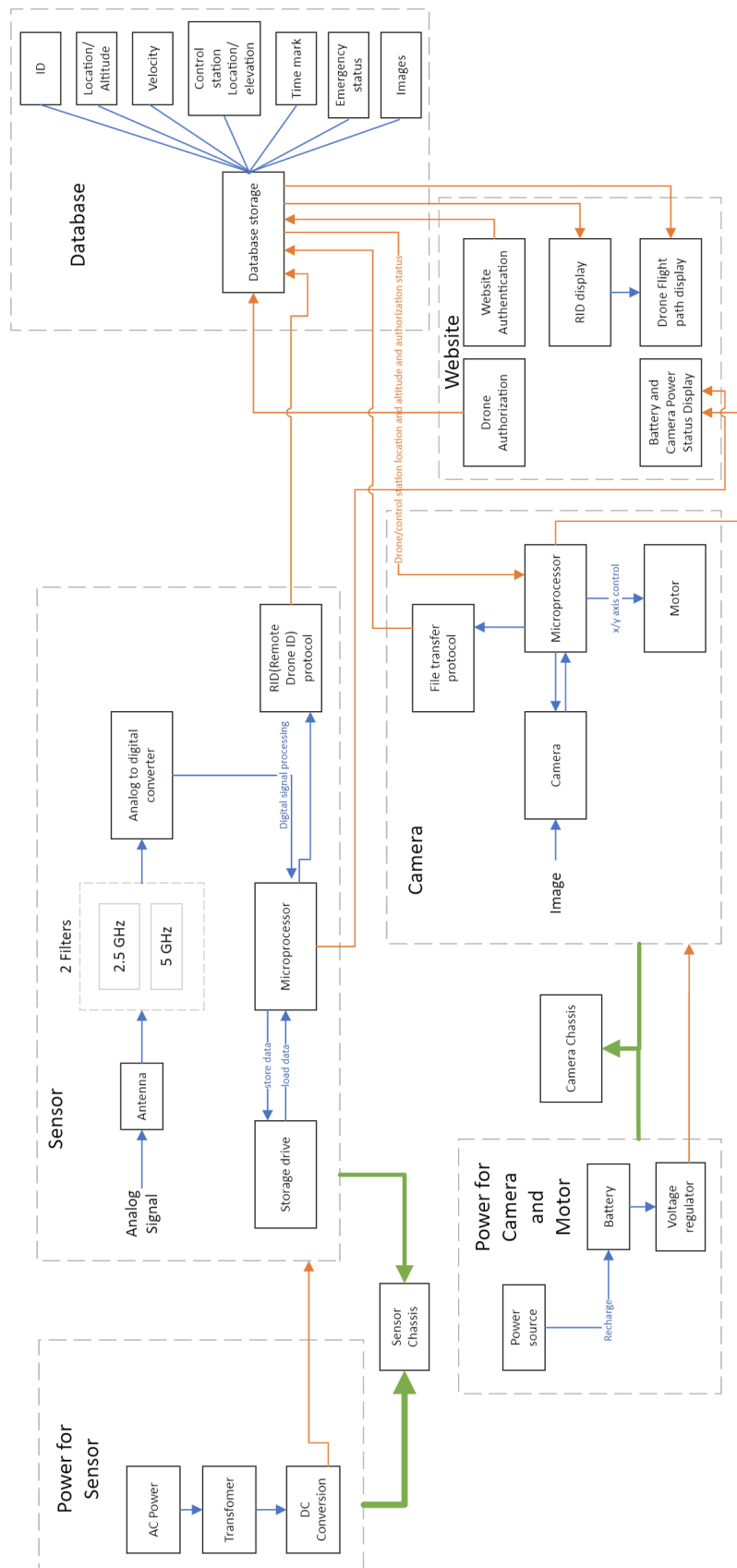[8] "856 data security and handling policy," Tennessee Technological University, Available: https://tntech.navexone.com/content/dotNet/documents/ [Accessed Feb. 19, 2024].

Database

ID | Location/Altitude | Velocity | Control station Location/elevation | Time mark | Emergency status | Images

Database storage

Website

Website Authentication
Drone Authorization
RID display
Drone Flight path display
Battery and Camera Power Status Display

Drone/control station location and altitude and authorization status

Sensor

RID(Remote Drone ID) protocol

Analog to digital converter

2 Filters
2.5 GHz
5 GHz

Antenna

Microprocessor

Digital signal processing

Analog Signal

store data
load data

Storage drive

Camera

File transfer protocol

Microprocessor

x/y axis control

Motor

Camera

Image

Camera Chassis

Power for Camera and Motor

Battery
Voltage regulator

Power source

Recharge

Sensor Chassis

Power for Sensor

AC Power
Transfomer
DC Conversion

Fig. 1. Block Diagram