Department of Computer Science & Engineering
The University of Texas at Arlington

# Project Charter
# CSE 4316: Senior Design I
# Fall 2022

# Team Mercury
# ARGOOSE-Counter Drone Tracking

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## REVISION HISTORY

| Revision | Date | Author(s) | Description |
|---|---|---|---|
| 0.1 | 9.23.2022 | AN | document creation |
| 0.2 | 10.02.2022 | AN, JG, SP, NS, MR | complete draft |

# Contents

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# 1 Problem Statement

Due to the massive and widespread increase in the use of civilian drones in recent years, concerns pertaining to the protection of physical privacy have gotten more relevant. Whether such drones are used for recreation or not, the likelihood of them trespassing in private areas is substantially more possible. This issue demands a surveillance solution that is not too resource-intensive for, say, a dweller who wants to monitor drone activity over their backyard.

# 2 Methodology

Our project is to provide a non-militarized, partially DIY surveillance system that identifies and tracks drone activity over a small area, ie. an area that is open to intrusive aerial surveillance. It is not necessarily an anti-drone system, but rather one that reports trespassing drone activity. Currently, the design is an embedded system that uses sensorial data to track drone activity and relay that information to the user through a web app interface.

# 3 Value Proposition

The Argoose project is one that strives to ensure security in military entities, companies, and every day people. Drone detection has solutions, but not many of the solutions are universal and compatible with every situation. Probably the most widely used technique for drone detection is high-resolution radar and that requires a technician for effective use [2]. The solution that Argoose provides is a readable map interface for anyone to use, on top of cost-effective node sensors to detect drones. The value that it gives to our sponsor, Christopher Mcmurrough, is the ability to sell the solution to companies and government entities; whether that be in the form of a product or a patent. The market works off of supply and demand, and with an increase in technological advances in the drone department, the demand for drone detection security systems will only increase, and yet the supply for these systems have remain limited; therefore, boosting the value of our system.

# 4 Development Milestones

- Project Charter first draft - October 2022
- System Requirements Specification - October 2022
- Architectural Design Specification - November 2022
- Demonstration of an acoustic sensor being able to detect sound - November 2022
- Detailed Design Specification - December 2022
- Demonstration of acoustic data shown in the web application - December 2022
- Demonstration of completion of first iteration - January 2023
- Demonstration of frequency detector being able to detect drone's radio frequency - February 2023
- Demonstration of radio frequency data of drone in web application - March 2023
- CoE Innovation Day poster presentation - April 2023
- Demonstration of the location of drones and sensors - April 2023
- Final Project Demonstration - May 2023

# 5 Background

Since the 9/11 incident, the United States have been seen using military-grade drones as an offensive weapon against enemies of the state [9]. Five years later, the Federal Aviation Administration started issuing permits for the use of drone in a consumer setting; this opened possibilities for the use of drones, whether it be for videography, entertainment, or utility purposes. At the same time, this posed a threat to aviation security: a drone flying around an airport can cause a number of safety issues, due to how precise pilots have to be; drones can also be used as weapons, strapping explosive devices to them and flying them under radar; being quiet and low-profile, an additional use for drones can be espionage or spying [8]. All of these hazardous uses for drones are reasons why a drone detection system would be beneficial, whether it be for airport, military, or home security [4]. Currently, radar is the main mode of drone detection; however, radar by itself isn't always enough. First off, the type of radar would have to be of high-resolution, but even then, the radar wouldn't be able to distinguish the drone from other smaller flying objects like birds [2]. High-resolution radar would have to be supplemented with databases of stored signatures, alongside AI and machine-learning software to be able to completely distinguish drones from other flying entities. The sponsor of this project is Christopher D. McMurrough, a professor at the University of Texas at Arlington–our instructor for senior design. The intention for this project is to find potential customers by developing an attractive and alternative solution to drone detection; the applications of a light-weight and cost-effective drone detection system can prove to be both helpful and lucrative.

# 6 Related Work

Unmanned aerial vehicles have evolved rapidly over the past few decades leading to mass production of affordable drones so has its risks therefore there are many counter measures research done in the detection and tracking of the drones. Some are mentioned below:

- **Drone Police Department** [5]: Project by University of Colorado funded by Department of Homeland Security. The project explores the feasibility of inexpensive RF-based detection of the presence of drones and examines whether physical characteristics of the drone, such as vibration and shifting, can be detected in the wireless signal transmitted. The downside of this project is that it works for seven different types of drones which emit radio frequency and the drones which do not emit radio frequency will not be detected by this software.

- **Automated Drone Detection Using YOLOv4** [7]: A research paper published by the Department of Computer Science and Information Systems of Texas AM University which designed an automated drone detection system using YOLOv4. YOLO is a one-stage object detection model. The model is trained using drone and bird data-sets acquired from the public data-sets. Detecting drones at various altitudes are difficult due to their small size and speed as well as the existence of drone-like objects.

- **Eye in the Sky** [6]: Drone Detection Tracking System: It is an Airport Cooperative Research Program introduced in the University Design Competition for Addressing Airport Needs conducted by the University of Rhode Island. There are two project components to this project, one is to provide the airport the ability to detect when a drone enters the critical airspace surrounding an airport and to inform the operator if the drone is within the 5 mile safety buffer around an airport. It uses GigE Vision Camera with MATLAB to implement it. The cost aspect of this project made it difficult to be relevant to our project.

- **EchoGuard** [3]: It is a product from EchoDyne which uses ultra-low SWaP ESA radar that detects and tracks drones in unauthorized areas. It rapidly and accurately slews other sensors such as PTZ optical cameras for continuous eyes-on-object, even at high zoom levels and while tracking fast moving targets. Radars are expensive and this uses a military radar which are seriously expensive.

- **Drone Detection and Defense Systems** [1]: The research supported by the Romanian Ministry of Education and Research. The research describes their our own solution that was designed and implemented in the framework of the DronEnd research project. The DronEnd system is based on RF methods and uses SDR platforms as the main hardware elements.

# 7 System Overview

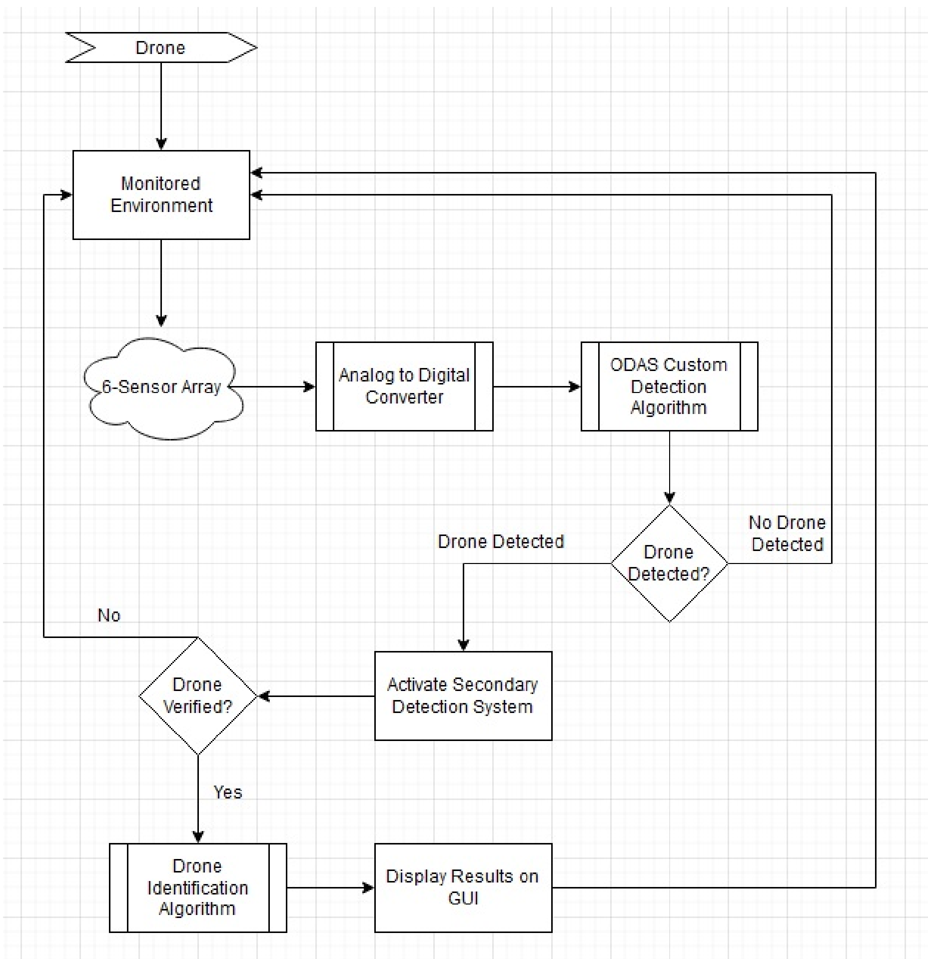



Figure 1: Drone Detection Prototype Schematic

Under the assumption that the UTA provided drone for testing will operate in a particular frequency band for its rotor spin; The ArGoose system will be calibrated to identify this frequency to detect and identify directional components for the intruding drone. To accomplish this goal, the system will contain a continuous detecting loop utilizing a six-sided hexagonal sound array attached to a Raspbery Pi monitoring system. When the drone enters within the range of the system, the audio sensors will pick up the frequency assigned and forward this information to an internal audio to digital converter located within the Respeaker sensor array. After conversion, the data will be forwarded to a system called ODAS (Open

Embedded Audition System) that will be loaded on the Raspberry Pi. This open-source software contains the foundation used to establish directional audio detection. With ODAS as a foundation, custom code will be constructed to limit the detection bandwidth to the necessary frequencies and eliminate noise that is detected and unimportant for our purpose. After proper processing and successful drone detection, the system will activate its secondary sensor suite, at this time an RF detection system and identify the RF signal of a nearby drone. The RF for drones follow the same pattern as the rotor sound generation and the detection algorithm will locate based on the particular bandwidth that a drone may operate in. By using the directionality provided by ODAS and the sound array, the RF will be focused on a particular area to detect the offending drone, so as to limit cross contamination from multiple sources. With verification of these two systems both detecting a possible drone, The data collected by ODAS to identify directionality as well as the RF details collected on the operating range of the drone and any telemetry that has been calculated will be forwarded to a web-based user interface for human assessment and action.

# 8 Roles & Responsibilities

Stakeholders of a project are considered people or groups who are interested with the project's outcome. In our project, the primary stake holder is our professor, Dr Christopher McMurrough who assigned the project. He will be supervising our progress and work flow, suggesting to make necessary progress and grading it. Additionally the team members of the project and anyone testing and using it are also considered as stakeholders. The point of contact from the sponsor will be Dr Christopher McMurrough and from our team will be James Grumbles who will communicate through a channel on Microsoft Teams. The team consist of five members with James Grumbles who will be handling hardware design and signal processing, Augustine Nguyen handling signal processing and UI design , Nirdesh Sakh working on the UI implementation and machine learning model, Mahin Roddur working on result processing using machine learning and Sanyogita Piya working on data analysis. The team will have Augustine Nguyen as product owner who will be providing the root GitHub sources for the semester. The scrum master role will be changed periodically with having each team member an opportunity to become a scrum master. There will be at least two scrum meetings per week while will be 15 to 30 minute time-boxed planning event to track the progress and coordinate with the development team.

# 9 Cost Proposal

The budget will be $800 (can increase at the discretion of Professor Mcmurrough). The money will come from UTA. At this time our expectation is that the components will require a budget of $400; this will include things like sensors and micro-controllers. Our fabrication costs will be estimated at $200 dollars, and the software takes the remaining budget with $200.

## 9.1 Preliminary Budget

| Preliminary Budget | Allocated Budget |
|---|---|
| Components | $400 |
| Fabrication | $200 |
| Software | $200 |

## 9.2 Current & Pending Support

Currently our main funding source is from UTA. There hasn't really been any potential funding sources because this isn't currently a sponsored project. The current funding source is from the UTA CSE department, at a budget of $800.

## 10 Facilities & Equipment

The main lab space that will be utilised is the work lab provided by the senior design course at UTA in ERB 335; it will most likely be our main area of work, especially when tinkering with hardware. In terms of makerspaces, UTA provides that equipment in their library and in Nedderman Hall. There is no guarantee that we will be using the makerspace equipment, but it's something that we can resort to in order to solve problems or implement features. For testing grounds, UTA has designated safe fly zones; places with high traffic like dorms or the library mall are absolutely prohibited, so we are relegated to the following places:

- The UTA Ballpark (as long as there's no event going on)
- The Maverick's Activity Center indoor soccer court (with an appointment)
- Inside College Park Center (with an appointment and 107 or greater pilot certification)
- The UTA Research Institute (with an appointment)

In terms of equipment:

- drone (no purchase, UTA provided)
- Raspberry Pi (no purchase, internally provided)
- TM4C123GH6PMI Microcontroller (no purchase, internally provided)
- Respeaker 6-mic Array with ADC (purchase)
- PiJuice rechargeable battery (purchase)

## 11 Assumptions

- The project will be completed by May 2023
- The funding for this project will be provided by University of Texas at Arlington and is USD 800 or more if needed.
- A preliminary design detecting an aerial object will be available at the end of fourth sprint cycle.
- The installation site should not be crowded and noisy with ambient sounds and noise because the performance of acoustic sensors degrades drastically in such conditions.
- The detection range should not exceed 500m because the sensor will not be able to detect drones in high altitude.
- The detection will be configured specifically to a drone determined by UTA.

## 12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by May, 2023
- Limited types and number of sensors can be integrated in the Raspberry Pi/embedded system

- Team members will not be available to work full time on the project since they are currently full time students.
- Total development costs must not exceed $800
- Information relay from sensor system to web app through university WiFi would need approval.

# 13 Risks

Since our project is a combination of both hardware and software components, we will face difficulties in both parts of the project. So, we have mentioned risk which might affect us in both the software and hardware parts of the project. Mitigation strategies will be discussed in future planning sessions.

| Risk description | Probability | Loss (days) | Exposure (days) |
|---|---|---|---|
| Delays in shipping of the parts needed | 0.50 | 20 | 10.0 |
| Team member not able to contribute due to flu or COVID-19 | 0.4 | 20 | 8.0 |
| Miscommunication during the coding periods among team members | 0.30 | 20 | 6.0 |
| Internet access not available at testing site | 0.30 | 7 | 2.1 |
| Failure in the hardware components | 0.30 | 30 | 9.0 |

Table 1: Overview of highest exposure project risks

# 14 Documentation & Reporting

## 14.1 Major Documentation Deliverables

The major deliverables are this project charter, system requirements specification, architectural design specification, and detailed design specification. These are the main documents that will be turned in during the first half of the project. Each of these document will be prepared with the co-operation of the whole team and stored in team's github as we move forward with the project. These documents will also be updated as needed during the course of the project.

### 14.1.1 Project Charter

This document will be maintained as a team and updated during each sprint if any requirement is edited, added or removed. The initial version will be delivered on October 3rd, 2022 and the final version will be delivered along with the complete project on May of 2023.

### 14.1.2 System Requirements Specification

This document will be maintained as a team and updated as needed. The requirements will not be edited as much as other documents, but it will be updated if the team decides to add or remove some parts. The initial version will be delivered towards the end of October 2022 and the final version will be delivered along with the complete project on May of 2023.

### 14.1.3 Architectural Design Specification

This document will be maintained as a team and updated frequently during the first half of the project. In the second half as we progress in the project and we have a solid structure for the project, it will be updated few times. The initial version will be delivered on November of 2022 and the final version will be delivered along with the complete project on May of 2023.

#### 14.1.4 Detailed Design Specification

This document will be maintained as a team and updated frequently during the initial stages. However, it will not be updated much after the completion of the design of the project. If a major change happens in the project, it will be updated accordingly. The initial version will be delivered on October 3rd, 2022 and the final version will be delivered along with the complete project on May of 2023.

### 14.2 Recurring Sprint Items

#### 14.2.1 Product Backlog

The items will be added after the discussion with the whole team after splitting up tasks so that no item on the backlog is too big. These items will be prioritized according to the need for the software. The decisions will be based on the majority vote. The software to maintain and share the product backlog with team members and stakeholders will be Jira.

#### 14.2.2 Sprint Planning

Each sprint will be planned before the beginning of the sprint. The backlog can be updated during the sprint. In Senior Design 1, there will be 4 sprints. In Senior Design 2, there will also be 4 sprints.

#### 14.2.3 Sprint Goal

The Sprint goal is decided by the group together with some feedback from the sponsor and customers of the project.

#### 14.2.4 Sprint Backlog

The team together will decide the backlog items and they will be kept in the Jira Board by the scrum master. The backlog will be maintained by the whole team as they progress in their allocated tasks with options like in-progress, done, etc.

#### 14.2.5 Task Breakdown

Individual task will be assigned by group discussion and the preference of each member. If there is a conflict, then the group leader for the sprint will decide how the conflicted task will be divided. Time spent on tasks will be documented using man hour.

#### 14.2.6 Sprint Burn Down Charts

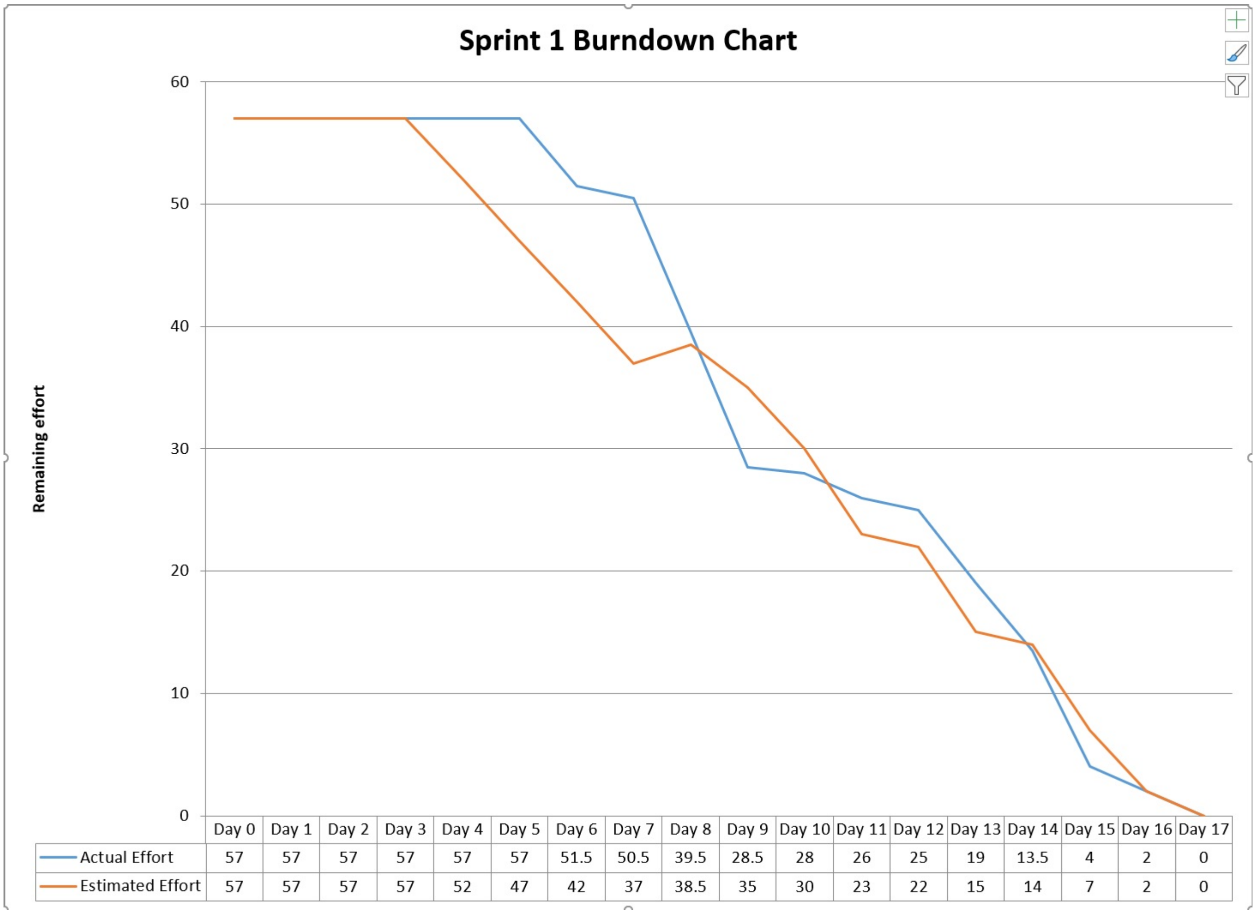
The scrum master will be responsible for generating the burn down charts for each sprint. The Jira Board has a feature to keep track of time spent on each task and Jira Board will create a burn down chart accordingly.

#### 14.2.7 Sprint Retrospective

The Sprint retrospective will be handled after the day of completion of each sprint. As a group, problems faced, lessons learned, ways to improve communication and the allocation of task will be documented. As individuals, lessons learned and peer reviews will be documented. These are due according to the schedule provided by the professor.

#### 14.2.8 Individual Status Reports

In the progress discussion meeting, each member will discuss the progress made by them and the problems they faced. The key items that will be included in the report will be which items they have worked on, problems they faced, if they need any assistance, etc.




| | Day 0 | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 | Day 11 | Day 12 | Day 13 | Day 14 | Day 15 | Day 16 | Day 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual Effort | 57 | 57 | 57 | 57 | 57 | 57 | 51.5 | 50.5 | 39.5 | 28.5 | 28 | 26 | 25 | 19 | 13.5 | 4 | 2 | 0 |
| Estimated Effort | 57 | 57 | 57 | 57 | 52 | 47 | 42 | 37 | 38.5 | 35 | 30 | 23 | 22 | 15 | 14 | 7 | 2 | 0 |

Figure 2: Sprint Burn Down Chart

#### 14.2.9 Engineering Notebooks

The engineering notebook will be updated after a change is brought up in the project. At a minimum, it will be updated bi-weekly which is the length of each sprint. There will be no minimum amount of pages. Team members will be each others' witness and will keep each other accountable.

### 14.3 Closeout Materials

#### 14.3.1 System Prototype

The system prototype will include Acoustic and RF detecting sensor station utilizing a raspberry pi connected to a microcontroller and ADC chain. This chain will connect to an RF detection circuit as well as a four array acoustic sensor tower. Currently, we have decided not to have Prototype Acceptance Test. The protype will be demonstrated off-site. We have shortlisted several locations at UTA and will be decided later on for the demonstration. Currently, we have not decided on whether we will have a Field Acceptance Test or not.

#### 14.3.2 Project Poster

Currently, this has not been discussed and will be done in the later part of the project.

#### 14.3.3 Web Page

The project web page will include the GUI of real time drone tracking. The tracking will be shown suing satellite image/Google Maps and location services will be displayed of the trackers. The completion of the web page also highlights the completion of the project and it will be delivered at closeout as a complete project.

#### 14.3.4 Demo Video

Demo video will show the real time drone tracking mechanism. The website will also be shown. We will not include a B-reel footage. The demo video will be around 10 minutes long and it will cover the mechanism used by the drone tracker , sensors used to detect drones and real time drone tracking and working of our website.

#### 14.3.5 Source Code

Source code will be maintained through github which is a version control system. Source code will be accessible to the sponsor directly through github. Currently, there is no plan for the project to be open sourced.

#### 14.3.6 Source Code Documentation

The source code will be well commented and proper formatting will be used by every coder. We will be using Doxygen and we will provide the documentation in pdf format.

#### 14.3.7 Hardware Schematics

Currenlty, we are not sure whether we will use the PCBs or not. We will update this section as we progress forward in the project.

#### 14.3.8 Installation Scripts

The web application of the project will be present online and will be accessible easily to the customer. Once the sensors are activated, data generation will begin and stored in the database. The data matching the criteria for drones will be then displayed on the web page which can be easily viewed by the customer. The customer will need to place multiple sensor towers in the desired location for the data generation to begin. User guide will be provided along with the completion of the project for the use of the product.

#### 14.3.9 User Manual

A digital user manual will be created towards the end of the project that describes all major parts of the project. A short demo video will also be provided on how to use the product.

## References

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