# Energy vs. Data Quality in Drones Monitoring

Design Document

Team 33
Client/Advisor: Professor Goce Trajcevski

| Team Member | Roles |
|---|---|
| Noah Kelleher | Lead Communicator |
| Ricardo Ramirez | Team Organization |
| Adnan Salihovic | Client Interaction |
| Nathan McKay | Testing |
| Jonathan Kelly | Individual Component Design |
| Hengwei Chen | Inter-Component Tester |

Team Email: sdmay22-33@iastate.edu
Team Website: https://sdmay22-33.sd.ece.iastate.edu/

# Executive Summary

## Development Standards & Practices Used

There are several development guidelines, methodologies, tools, and standards that this project will use in its implementation next semester. These can be seen listed below:

- Agile
- Black-box testing
- Object-oriented programming
- Aerial Communications and Networking Standards, IEEE P1920.1
- IEEE 820.11 - IEEE Standards for Wireless Networking
- IEEE Std 1937.1 - IEEE Standard Interface Requirements and Performance Characteristics of Payload Devices in Drones
- IEEE 1008-1987 - IEEE standard for testing (unit/integration/...) - IEEE Standard for Software Unit Testing

## Summary of Requirements

There are several requirements that must be met by this project by the end of next semester. These are listed below:

- Develop a desktop application that allows users to input various desired drone configurations (such as the number of drones and grid size) and to analyse the resulting energy tradeoffs and flight paths of the simulation
- Design and implement flight pathing algorithms and data analysis algorithms for the simulation that determine flight paths, battery usage, and range
- Implement a server that allows the storage of accurate information for battery expenditure, flight time, and saved drone/simulation configurations
- Develop a mobile application to observe results from the simulation via notifications

## Applicable Courses from Iowa State University Curriculum

- COM S 227: Object-oriented Programming
- COM S 228: Introduction to Data Structures
- COM S 309: Software Development Practices
- COM S 311: Introduction to the Design and Analysis of Algorithms
- CPR E 288: Embedded Systems I: Introduction

- CPE E 310: Theoretical Foundations of Computer Engineering
- EE 201: Electric Circuits
- EE 224: Signals and Systems I
- EE 230: Electronic Circuits and Systems
- EE 303: Energy Systems and Power Electronics
- SE 319: Construction of User Interfaces
- SE 329: Software Project Management
- SE 339: Software Architecture and Design

## New Skills/Knowledge acquired that was not taught in courses

There are several skills not directly taught in courses that this team will acquire as a direct result of working on this project. These can be seen listed below:

- Python
- Simulation development
- Hardware research and selection
- Visualization of real world systems
- Working with significant budgetary constraints
- Plecs

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## List of figures/tables/symbols/definitions

# 1 Team

## 1.1 Team Members

Adnan Salihovic, Hengwei Chen, Jonathan Kelly, Nathan McKay, Noah Kelleher, Ricardo Ramirez

## 1.2 Required Skill Sets For Your Project

Battery testing, simulation through software, Python, database systems, UI design

## 1.3 Skill Sets Covered By The Team

Low level programming (C and C++), embedded systems, data parsing/storing, cyber security, Android, Linux, UI design, object oriented programming (Java), databases, data science, software testing, Python

## 1.4 Project Management Style Adopted By The Team

Waterfall was used first semester for predefined and well understood requirements as well as base level implementation of drone control and information gathering.

Agile will be used next semester for the testing and updates of the simulation as well as for tasks that arise from constraints and revisions.

## 1.5 Initial Project Management Roles

Lead Communicator (NK), Team Organization (RR), Client Interaction (AS), Testing (NM), Individual Component Design (JK), Inter-Component Tester (HC)

# 2 Introduction

## 2.1 Problem Statement

Drones have become increasingly popular in commercial use over the last twenty years. This is partially due to the technology having become more affordable to the average consumer, but also because drones have a wide variety of applications. They can be used for recreation, but they also have a lot of commercial use cases. However, drones are limited by their flight time, so optimizing this flight time can make a massive difference in specific applications.

The goal of this project is to develop a system that will enable investigating the trade-offs between energy expenditure and operational lifetime in collaborative drone surveillance systems. The objective is to have a simulation-oriented solution which, in turn, will also be tested with a small fleet of drones. Specifically, this project will consider scenarios where an area that can be covered by a single drone, may still need another "extra" drone to complete the surveillance task. In such settings, we will investigate the overall operational lifetime of the fleet and enable planning of battery-swapping.

## 2.2 Requirements and Constraints

This project has numerous different requirements that can be divided and organized into several categories which can be seen below:

a. Functional Requirements
    i. The drones must be able to call other drones for help when the battery is low
    ii. The system must be able to estimate the energy/battery status of:
        1. Individual drones
        2. Lifetime of the fleet as a whole
    iii. The application should enable investigating of the trade-offs in an "offline" manner
b. UI Requirements
    i. The user needs to be able to control the drone flight paths
    ii. The user will be able to turn on/off the drones
    iii. The user will be able to designate an area to map
    iv. The user must be able to select which drones are active

v. The user must be able to control when a drone will help another drone

c. Resource Requirements
   i. The project will require 2-3 usable/testable drones
   ii. The project will require a server
   iii. The project must be completed by May 2022 (Constraint)
   iv. The weekly load should not exceed 4 hours per person, or 720 total hours (Constraint)
   v. The purchases should not exceed $10,000
   vi. Familiarize with FAA protocols for flying drones (Constraint)
d. Qualitative Requirements
   i. The final product must be able to simulate drone surveillance of an area while also preserving battery usage as much as possible.

## 2.3 Engineering Standards

1. Aerial Communications and Networking Standards, IEEE P1920.1
2. Wireless Networking, IEEE 820.11
3. IEEE Standard Interface Requirements and Performance Characteristics of Payload Devices in Drones, IEEE Std 1937.1
4. IEEE 1008-1987 - IEEE Standard for Software Unit Testing

## 2.4 Intended Users and Uses

This project's goal is to provide a system that will optimize the flight paths of an autonomous fleet of drones. As such, there are many potential commercial use cases for a system like this, many of which are described below:

1. Agriculture
   a. Drones survey fields to monitor crop growth and health
2. Emergency Services
   a. Drones conduct damage assessment for areas affected by natural disasters
      i. Wildfires
      ii. Floods
      iii. Volcanic Activity
      iv. Weather damage (hurricanes, tornados, etc.)
   b. Firefighters

i. Use multiple drones to estimate the shape of the fire
ii. Guide multiple fleets/vehicles.

c. Police use
   i. Survey large areas of land in missing persons cases
   ii. Track crimes

3. Transportation of Goods
   a. Delivering supplies for disaster relief
4. Infrastructure
   a. Inspect damage to roads, buildings, etc. without physically sending people

# 3 Project Plan

## 3.1 Project Management/Tracking Procedures

We will be using a mix of waterfall and agile. For predefined and well understood requirements we will use waterfall, like the base level implementation of drone control and information gathering. Agile will be used for tasks that arise from constraints and revisions made while continuing to work on the project, such as training to operate and the drones. Agile will also be used for testing and small updates in the second semester, for issues such as battery drainage differing from expected during field tests.

Our group will be using a combination of GitHub, Trello, and Google Docs for this project. GitHub will mainly be used as a repository for code. Trello will be our main project management tool. It will allow us to track the progress of each stage of our project and mark them for completion. Google docs will be used as a repository for group documents. We will also use Slack and Discord as team communication platforms. In Slack, we will create distinct channels based on project tasks. Discord will be used for general communication.

## 3.2 Task Decomposition

Developing this solution requires that the project is divided into numerous tasks, each with their own planned completion dates. The decomposition of these tasks can be seen below in Table 1:

Table 1: Project Tasks

| Task # | Planned Completion Date | Task Description |
|---|---|---|
| 1 | 10/9/2021 | Finish research of various models and decide on a drone |
| 2 | 10/24/2021 | Finish research and selection of development software for the drone simulation application |
| 3 | 11/01/2021 | Preliminary design of simulation complete |
| 4 | 12/10/2021 | Complete the design document and presentation |

| | | |
|---|---|---|
| 5 | 01/30/2022 | Complete role assignments of team members and begin simulation development |
| 6 | 02/20/2022 | Finish field testing of drones |
| 7 | 03/6/2022 | Complete alpha version of simulation software and gain user feedback |
| 8 | 03/21/2022 | Have finished beta of complete system |
| 9 | 04/10/2022 | Finish initial draft of final presentation |
| 10 | 04/24/2022 | Complete the final version of project |
| 11 | 05/01/2022 | Final touches on project and presentation |

## 3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

The milestones for this project have a 1-1 correspondence to the tasks shown in Table 1. There are several metrics and evaluation criteria that can be used to assess both the drones testing and simulation software portions of this project. These are defined below:

Field Testing:

- Flight duration: How long can each drone fly on average? How long at different speeds? What types of weather do the drones operate the best in? Does the drone use more or less battery life hovering or moving?
- Flight speed: What are the maximum and minimum speeds of the drones? Is there a particular speed that maximizes battery life?
- Maneuverability: How long does it take the drones to spin? How long does it take the drones to reach a specified height?

Simulation/software:

- Unit tests: What percentage of tests pass?
    - Line and branch coverage percentage for all tests
- Accuracy: Is the data received from the drones accurate? How accurate?
- Scalability: Can the simulation scale to include more drones? Can the screen refresh quickly enough to present all information?
- Bugs: Does the software have many bugs? Are any of them program breaking?

## 3.4 Project Timeline/Schedule

Semester 1:

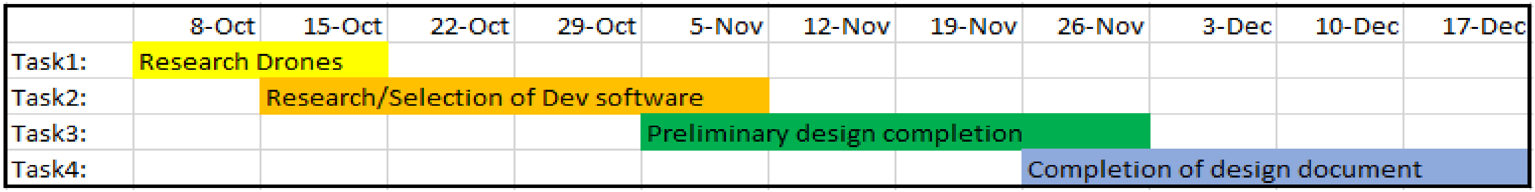


Figure 1: Gantt Chart October-December

Semester 2:

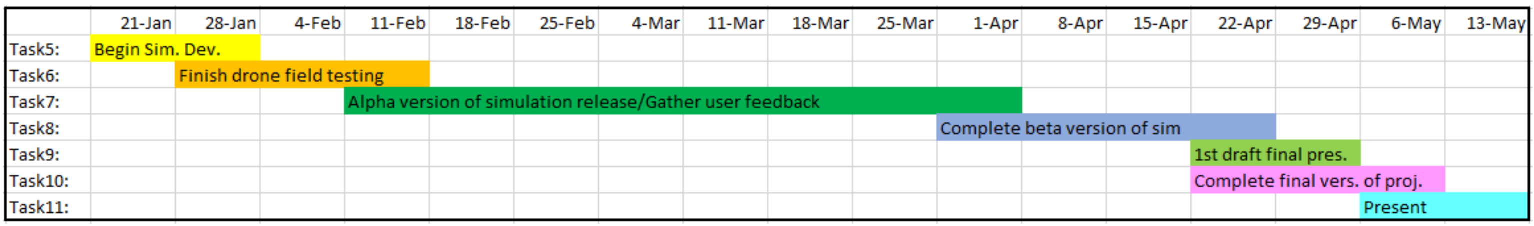


Figure 2: Gantt Chart January-May

## 3.5 Risks And Risk Management/Mitigation

- Task 1) Drones on the market may exceed the budget constraints: 10%
  - Many modern drones cost less than $500. Higher quality drones are in the $1000-2000 range. With a target of 4 drones and a budget of around $10,000, the drones purchased should fall around $6,000; this is within the budget constraint
- Task 2) Applications may not be compatible with selected drone: 20%
  - There is a possibility that the drone may not function correctly with our selected development software. A workaround of selecting new software could be used
- Task 3) Preliminary software design lacks many required simulation features:70%
  - Required features will be added in future releases
- Task 4) N/A
- Task 5) Team members fall behind on tasks: 80%
  - Discuss any potential problems and adjust deadlines if necessary
- Task 6) Drone malfunctions or breaks during field testing: 30%
  - A drone could malfunction during field testing due to weather or user error. If this happens, more testing will occur between the remaining drones. If the budget permits it, another drone could be purchased
- Task 7) Simulation software is very buggy or does not work as intended: 80%

    - Iron out bugs and rework code for next release
    - Some desired functionality is incompatible with the selected drones: 50%
    - Find some workaround if possible; otherwise, either find new software or remove the feature
- Task 8) Same as Task 7
- Task 9) N/A
- Task 10) Major bugs discovered or more testing required: 20%
    - Fix issues and implement tests quickly or remove features if necessary
- Task 11) N/A

## 3.6 Personnel Effort Requirements

The team roughly estimated the amount of man-hours necessary to complete each task for this project. The estimates can be seen in Table 2 below:

Table 2: Estimated Time of Tasks

| Task # | Estimated Completion Time (hours) |
|---|---|
| 1. Finish research of various models and decide on a drone | 18 (3 hours * 6 people) |
| 2. Finish research and selection of development software for the drone simulation application | 30 (5 hours * 6 people) |
| 3. Preliminary design of simulation complete | 24 (4 hours * 6 people) |
| 4. Complete the design document and presentation | 27 (4.5 hours * 6 people) |
| 5. Complete role assignments of team members and begin simulation development | 16 (2.5 hours * 6 people) |
| 6. Finish field testing of drones | 18 (3 hours * 6 people) |
| 7. Complete alpha version of simulation software and gain user feedback | 30 (5 hours * 6 people) |
| 8. Have finished beta of complete system | 558 (93 hours * 6 people) |
| 9. Finish initial draft of final presentation | 12 (2 hours * 6 people) |

| | |
|---|---|
| 10. Major systems fully implemented and tested | 18 (3 hours * 6 people) |
| 11. Complete the final version of project and presentation | Total :720 (120 hour* 6 people) |

## 3.7 Other Resource Requirements

A set of 3-4 drones will be required for testing and simulations. A server will also be required. The project is required to be completed by May 2022. It also requires familiarity with FAA protocols for operating the drones. The weekly load should not exceed 4 hours per person, or 720 total hours.

# 4 Design

## 4.1 Design Context

### 4.1.1 Broader Context

Our design is targeted to include the collaborative surveillance of an area by a set of drones. It will include reasoning about different types of collaboration as well as the tradeoffs between energy expenditure and drone lifetime and responsiveness. This design could be used in a variety of scenarios such as wildfire surveillance, crime monitoring, infrastructure inspection, crop analysis, etc. which can all be seen below in Table 3:

Table 3: Timeline of Milestone Papers on Spatial Crowdsourcing

| **Area** | **Description** | **Examples** |
|---|---|---|
| Public health, safety, and welfare | Improving surveillance capabilities can yield more effective emergency responses to various situations. | Locating survivors of natural disasters.<br>Crime monitoring and alerting in Abu Dhabi [6] |
| Global, cultural, and social | The project will not conflict with any particular ethnic or racial group. | To the contrary, infield experiments will be conducted under strict safety protocols, and the development of the system will not require interactions that will violate any sensitivity of societal groups. |

| | | |
|---|---|---|
| Environmental | Our project aims to have only positive environmental impacts. | Can be used to improve crop analysis or wildfire management<br>Traffic monitoring can improve management (in terms of orchestrating lamps and stops), thereby potentially decreasing the vehicular resources used.<br>More efficient energy usage will cut down on power used to fuel our system as well |
| Economic | The project is expected to have positive economic impacts in both rural and urban settings. | Large scale field monitoring can improve yield of plants by assigning watering and pesticide spraying.<br>Crime and traffic monitoring can help in more effective management of resources (e.g., police and firefighters), as well as other forms of emergency response. |

### 4.1.2 User Needs

Planners must be able to test the assignment of fixed drones versus floating drones. They must also reason about the size of the cells for the geographic regions to be assigned to a fixed drone. Planners need to investigate various operational scenarios through the simulation software. Lastly, they need to comply with safety regulations regarding the competent uses of the drones.

Domain experts need to provide suggestions to planners in terms of range parameters. An example of this could be agricultural experts specifying wider portions of fields because changes may not be as frequent in certain areas. Police officers could specify smaller regions to monitor during social events and rush hours. Domain experts must also provide details on the terrain and standard weather conditions of an area for optimal drone flight.

### 4.1.3 Prior Work/Solutions

There has been a lot of literature in the last decade about use of drones in various application domains [1,3]. In addition, there has been numerous research works addressing various aspects of effective coverage and energy use of drones [2]. However, to our knowledge there has been no system that can enable domain experts irrespective of their specific domain to have a flexible system that will:

1. Investigate different collaborative policies for a fleet of drones.
2. Verify the results with an actual set of drones (and vice versa).

### 4.1.4 Technical Complexity

The project design will include various algorithms that must be implemented into the simulation desktop application, such as determining flight paths, battery usage, range, etc. The design will also include a user interface that must be flexible enough to provide the user the specification of several parameters of the target domain (e.g., the dimensions of the field to be monitored or a map of the city to be monitored, etc.) as well as a visualization of the outcome of the simulation analysis (e.g., graph with the energy expenditure, leftover battery life) in real time. The in field testing of the drones will have to be completed in a restricted environment to comply with safety regulations.

## 4.2 Design Exploration

### 4.2.1 Design Decisions

The design must consider financial constraints when selecting and purchasing the physical drones used for testing. We will determine the type of framework that will be used to store and visualize data. We will examine the extensibility and scalability of the solution (e.g., how easy it will be to add other algorithms and parameters to the design). Lastly, we will also consider what framework we must use for the communication between the desktop application and the server.

### 4.2.2 Ideation

For our drones purchase, there were several different parameters that we considered which can be seen below:

- **Average Flight Time/Battery Life** - Minimize time when a system is not available
  - How much energy it stores
  - How much time it takes to charge
- **Cost Per Drone** - Need to consider cost of the system in any situation

    - Ranging from $500 to $2000 per drone
- **Camera quality** - Depending on the use, the camera may need to be a higher quality
    - HD/4K
    - Recording capability
    - Camera zoom capability
    - Camera maneuverability
- **Range** - Some applications of the simulation may take place over a large area
    - Max altitude capability
    - Max distance from controller
- **Durability/resistant to damage** - May be used in dangerous situations
    - Waterproofing for rain
    - Max height to fall without damage
- **Accuracy of GPS data** - How accurately flight paths can be tracked
    - Average error from GPS location
- **Size and Weight** - Maneuverability, more 'tight' controls as well as storage
    - Wind resistant
    - Lightweight
- **Speed** - How fast its tasks will be done
    - Top speed

### 4.2.3 Decision-Making and Trade-Off

When we decide on a programming language to use, our main criterion will be the available packages/libraries for each language and how they could be used in the design. For the development framework, we must consider data visualization and communication tools. These decisions on the programming language and development framework have not yet been made at the time of writing. For the drones purchase, we considered factors such as the average flight time and the maximum data transmission distance. The drones purchases have been decided.

## 4.3 Proposed Design

### 4.3.1 Design Visual and Description

Drones will be purchased and used for testing so that the database can store accurate information such as battery expenditure and flight time for the drone model that is chosen. A server will contain the database storing that information and will communicate with the desktop simulation to provide accurate data that a user can use to simulate a fleet of drones communicating with one another to optimally survey an area with consideration to drone battery expenditure. This communication will most likely be done using Spring Boot as well as an SQL database. The desktop application will be designed using Python and Visual Studio Code because of the wealth of libraries available. Finally, the mobile app will be able to communicate with the desktop application so that it can receive notifications from the simulation. The app will be designed using Android and Java and Volley will be used for communication. This entire system can be visualized in Figure 3 below:

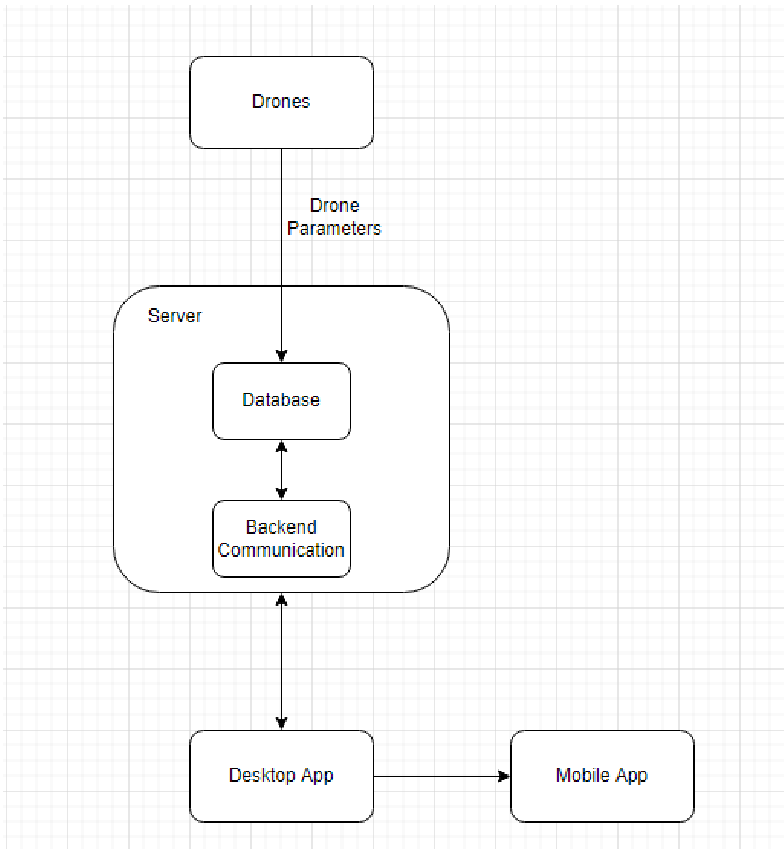


Figure 3: System Diagram
Communications Between Drones, Backend Server, and Desktop Application

For the simulation itself, a basic conceptual design can be seen in Figure 4 below:

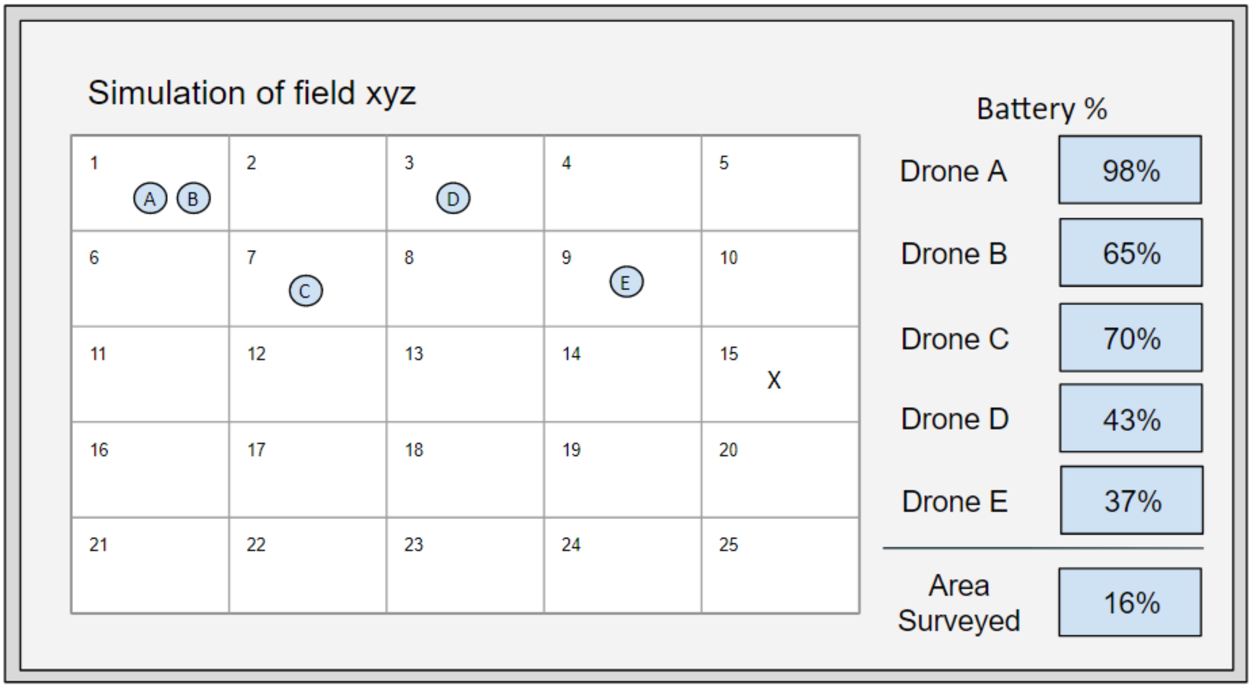


Figure 4: Simulation Conceptual Design

### 4.3.2 Functionality

Users of our design will be able to control the drones to move in specific and various ways, as well as verify the actual paths taken. For example, an agricultural expert could choose an optimal path for watering and pesticide application, as well as being able to compare real flight paths to the expected flight paths after completion. Our current design addresses these functional needs in a basic way, but needs more detail into how exactly flight paths will be tracked, as well as how large of a distance the drones will be able to cover.

For the Drone Selection we carefully researched different drone options on the market and decided what features would benefit our project the most. The first drone is the Parrot ANAFI which has very common drone specifications like the 25 minute flight time and the 4km transmission range. The main reason we selected the ANAFI is because it is a programmable drone which could be a necessary feature when trying to implement the algorithm into the drones. The second drone we selected is the DJI Mavic 3 which offers more realistic numbers to what would be seen out in the field because of its 46 minute flight time and the 15 kilometer transmission range.

### 4.3.3 Areas of Concern and Development

Our current concerns for the design include the scalability and validity of our solution. How easy will it be to add additional features and parameters to the solution to address more complex and diverse problems? How reliable will data verification be with only a small fleet of drones? To address these concerns, in the second semester we will proceed with agile development and try to devise multiple testing scenarios. This will allow us to efficiently and effectively deal with these concerns as they arise.

# 5 Testing

Some of the unique testing challenges in our project include the complexity of testing communications between frontend and backend software as well as testing drone attributes in real-world conditions. Below is our testing plan to handle these challenges.

## 5.1 Unit Testing

As shown in Figure 3, there are several distinct modules in our system. While some of them are servicing different contexts, in each case, there are certain identifiable units of development and implementation that are planned to be a part of a final deliverable. Below is a list of a few specific examples of identifiable elements:

1. Database
    - Insertion of new "maps" i.e., models of geographical regions of interest. We expect that the database will be able to allow multiple grid models to be stored to avoid specification from scratch.
    - Retrieval of the grid from the database. The database will be able to send stored grids to the desktop application to be used in a simulation.
2. Desktop Application
    - Parameters within the desktop application such as the number of drones and the sizes of cells within the grids will be adjustable. For scalability, adding new parameters will not break any existing functionality.
    - The flight planning algorithms should not impact the functionality of each other, even when new algorithms are implemented.
3. Drones Testing
    - Numerical data to test the usage and life of a battery. Using a multimeter to get accurate reading of the battery usage in different situations like roaming and full speed of the drone.

## 5.2 Interface Testing

There are several identifiable levels of interface testing:

1. The interface used for planning and observing drone movement
    a. Testing various page formats and map interactivity
2. The mobile interface for observing results and sending requests
3. Testing that the algorithms we are intending to use are optimized and efficient enough for a fleet of drones to work together while preserving energy expenditure.
4. We will also need to make sure that the data that is being used will be able to be used by the simulation to visualize a properly working drone surveillance system.

## 5.3 Integration Testing

There are several critical use cases that must be tested within our project including those listed below:

1. If the user inputs a predefined test area, the simulation will pull the test area from the database
    a. The simulation and database will need to communicate with one another; this will be tested by confirming the two can successfully communicate with each other and information that is pulled from the database can be seen on the simulation.
2. Communication between the database and the mobile application
    a. The requests for information can be tested with Volley acting as a faux mobile app for the purposes of simulating different requests and object types.

## 5.4 System Testing

We respectfully note that through integration tests 1 and 2, we will have achieved overall system testing. We will have captured units from different modules that need to be interfaced as well as module-wise integration towards enabling the functionality of the system.

## 5.5 Regression Testing

New additions should not impair the original functionality of the simulation, but instead should allow the user to have more options when using the simulation to get desired results. We need to ensure that the algorithms that we are using do not get affected in terms of effectiveness with additions of new features.

## 5.6 Acceptance Testing

As mentioned in section 5.4 (and 5.3), many of the functional requirements will be tested and evaluated as part of the integration and system testing. For example, for pulling a predefined testing area onto the simulation, the software will test for a successful communication with the backend and if the data was successfully pulled from the server. The client will be involved in the acceptance testing in both a functional and nonfunctional requirements sense. For example, the client will provide different activity scenarios in the geographical region of interest monitored by the drones.

## 5.7 Security Testing

While we recognize the importance of security protocols, this is not within the scope of this project. However, we will rely on existing mechanisms e.g., password protected accesses, basic encrypted communication protocols, etc.

## 5.8 Results

We will not have any quantifiable results this semester. In the next semester, we will follow Agile development.

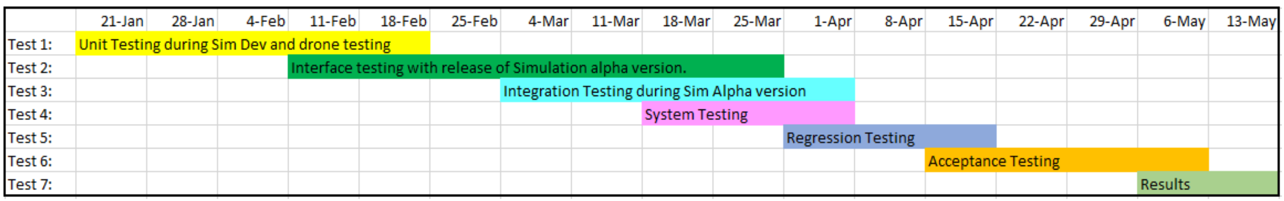


Figure 5: Gantt Chart Results January-May

# 6 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012 [4]

## 6.1 Areas of Responsibility

There are seven major areas of professional responsibility [ 4] which are defined in Table 4 below:

Table 4: Seven Areas of Professional Responsibility

| **Area of Responsibility** | **Definition** | **NSPE Canon** |
|---|---|---|
| Work Competence | Perform work of high quality, integrity, timeliness, and professional competence. | Perform services only in areas of their competence; Avoid deceptive acts |
| Financial Responsibility | Deliver products and services of realizable value at reasonable costs | Act for each employer or client as faithful agents or trustees. |
| Communication Honesty | Report work truthfully without deception and understandable to stakeholders | Issue public statements only in an objective and truthful manner; Avoid deceptive acts |
| Health, Safety, Well-Being | Minimize risks to safety, health, and well-being of stakeholders | Hold paramount the safety, health, and welfare of the public |
| Property Ownership | Respect property, ideas, information of clients and others. | Act for each employer or client as faithful agents or trustees. |
| Sustainability | Protect the environment and natural resources locally and globally. | Hold paramount the safety, health, and welfare of the public |

| | | |
|---|---|---|
| Social Responsibility | Produce products and services that benefit society and communities. | Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. |

Table 5: Seven Areas of Professional Responsibility Defined by ACM Code of Ethics

| **Area of Responsibility** | **ACM Code of Ethics** |
|---|---|
| Work Competence | 1.3 Professionals must be honest about their qualifications and their technical competence, including any limitations.<br>2.2 Professional competence includes both technical competence as well as soft skills such as communication, problem solving, and leadership. |
| Financial Responsibility | 1.7 Professionals must protect confidentiality in all situations except those that are unethical or illegal. Examples of confidentiality include client data, financial information, patents, etc. |
| Communication Honesty | 2.1 and 2.2 Professionals must be transparent in their communication within their organization as well as with the general public. |
| Health, Safety, Well-Being | 1.1 and 3.3 Professionals should work towards minimizing any potential threats to the health, safety, privacy, and personal security of the general public, clients, and employees. |
| Property Ownership | 1.2 and 1.5 Professionals must avoid any unnecessary or unjustified damage to any property or reputation. They also cannot claim private ownership of any body of work that is considered public or owned by another individual or organization.<br>1.6 Professionals must avoid taking credit for clients and others' information and designs, even in cases where copy-right has not been protected. |

| | |
|---|---|
| Sustainability | 1.1 Professionals must protect and promote environmental sustainability in all aspects of business and development. This should include both local sustainability as well as a global footprint. |
| Social Responsibility | 3.2 Organizations affect broader society. Organizations through procedures oriented toward quality, transparency, and the welfare of society- reduce harm to the public. Leaders should encourage full participation of computing professionals in meeting social responsibilities. Discouraging tendencies do otherwise.<br>3.1 Organizations should produce more towards the quality and welfare of society, reduce the harm to individual of public, and encourage the participation in meeting those responsibility |

## 6.2 Project Specific Professional Responsibility Areas

All seven of the professional responsibility areas defined in Table 4 can be applied to this project to some degree, and in each area, we have graded our performance:

**Work Competence:** Work competence applies well to our project. The main goal of senior design is to prepare ourselves to be able to use the skills and knowledge we have gained at Iowa State and adapt them to be able to function in an engineering team. Work competence is a key professional responsibility of a high performing teammate. This semester we have been performing adequately but as the next semester begins and each team member takes on more high-stakes responsibilities, work competence will turn into a high demand responsibility area.

**Financial Responsibility:** Financial responsibility applies well to our project; we have a budget for the project and it should be spent carefully and strategically so that it is not wasted. Our team is performing high in this aspect.

**Communication Honesty:** Communication honesty applies well to our project. We have had a lot of communication with our client and discussed how things are progressing with respect to different milestones. Our team is performing high in this aspect.

**Health, Safety, Well-Being:** This area has a loose application to our project. There is not a lot of risk involved with our project at its current stage, but ensuring we follow FAA regulations when flying the drones will be a priority when the time arises. Overall, our team is currently performing N/A on this aspect, but we hope to have a high rating when applicable in the future.

**Property Ownership:** We have applications of this responsibility in our project. Respecting and noting resources for our research on drones as well as various software recommendations has been a part of our planning since the start of our project, and we rate our performance as high in this category

**Sustainability:** Sustainability will be applied to our project in the future. Our project aims to test battery usage and flight time amongst other metrics, and getting accurate readings early on without repetitions will be our way of observing this responsibility. Currently, our performance is N/A.

**Social Responsibility:** This responsibility plays a role in our project. We hope to help many different fields by making our project usable in general situations, and leaving it to the specifications of our users. However, the specifics of actual integration haven't been strongly planned out yet. Thus, our current performance is medium.

## 6.3 Most Applicable Professional Responsibility Area

Work competence is important for our project and our group has demonstrated a high level of proficiency in it because our project is entirely based on the data that conducted research provides. We have had to conduct research on drones, simulation frameworks, and algorithms in order to satisfy the requirements and goals of our projects. Without conducting the research for these topics our project goal would be meaningless, without research we would not have a data backed way to improve drone battery life with regard to system efficiency. We will also have had to conduct the research in a timely manner due to the second semester being the beginning of production for the simulation application.

# 7 Closing Material

## 7.1 Discussion

At this moment we do not have any quantifiable results for the project. In the following semester we will find the main results for the project and if the requirements have been met.

## 7.2 Conclusion

This semester we have done research on drones, algorithms, and frameworks while also planning and constructing our projects main objective, which is to develop a simulation that allows a user to simulate a fleet of drones operating in a given environment efficiently while effectively preserving drone battery life.The goal for next semester is to develop a working simulation using the research we have conducted this semester and the drone testing that will be conducted in the beginning of next semester.

## 7.3 References


[1] Small Flying Drones: Applications for Geographic Observation
[2] Survey on Coverage Path Planning with Unmanned Aerial Vehicles
[3] Science, technology and the future of small autonomous drones
[4] Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment
[5] Unmanned Aerial Vehicle Coverage Path Planning Algorithm Based on Cellular Automata
[6] Dubai police will use citywide network of dornes to respond to crime


## 7.4 Appendices

### 7.4.1 Team Contract

**Team Name:** sdmay22-33

**Team Members:**

1) Jonathan Kelly
2) Nathan McKay
3) Ricardo Ramirez
4) Adnan Salihovic
5) Noah Kelleher
6) Hengwei Chen

**Team Procedures:**

1. Day, time, and location for regular team meetings:

    Tuesdays/Thursdays @ 4:30 Virtually through Discord

2. Preferred method of communication updates, reminders, issues, and scheduling:

    Email and Discord

3. Decision-making policy:

    Team Consensus

4. Procedures for record keeping:

    Shared text chat in Discord, updated by rotating members each meeting

**Participation Expectations:**

1. Expected individual attendance, punctuality, and participation at all team meetings:

    Each team member is expected to attend every meeting on time and participate unless the team was notified prior to the meeting.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

    Each team member will be expected to try their best to finish their respective assignments and ask for assistance should they not expect to be able to do so.

3. Expected level of communication with other team members:

    Each team member must be able to meet weekly unless mentioned prior to the meeting time. The team member must reach out after the meeting for an update on what was discussed at the meeting.

4. Expected level of commitment to team decisions and tasks:

    Team members will be expected to participate in team decisions and follow through with those decisions. If there are disagreements, team members are expected to voice those concerns and work together to address them.

**Leadership:**

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):

Team organization: Ricardo Ramirez

Client Interaction: Adnan Salihovic

Inter-component tester: Hengwei Chen

Individual component design: Jonathan Kelly

Testing: Nathan McKay

Team communicator: Noah Kelleher

2. Strategies for supporting and guiding the work of all team members:

Daily checking of Discord for issues that they may experience while working on the project. Github Issues and Commits can also be used for any coding problems that arrive.

3. Strategies for recognizing the contributions of all team members:

Contributions will be recognized based on team role as well as recorded authorship for any documentation or technical work (i.e., code having the author written, meeting minutes signed by team members).

**Collaboration and Inclusion:**

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

Majors: 2 EEs (Ricardo and Hengwei), 2 CprEs (Noah and Nathan), 2 SEs (Jon and Adnan)

Minors: 2 Data Science (Jon and Adnan),

Nathan: Strong with low level coding and embedded systems concepts. Experienced with data sorting and parsing.

Noah: Embedded systems and security focus areas. Strong background with Android mobile development and Linux systems.

Adnan: Strong mid level knowledge of Python and C. Experienced with R and Python pandas for data visualization and analysis. Low level knowledge with embedded systems.

Ricardo: Experienced with C and embedded systems concepts. Low level knowledge with linux systems. Mid level experience with power.

Hengwei: Good at low level coding and mathematics. Know a bit about c++ and python.

Jon: Experienced with Java, C, Python, Node.js, Linux, Junit testing and software system design

2. Strategies for encouraging and support contributions and ideas from all team members:

Make every team member an important part of the team. Allow each individual team member to share their voice and their vision and set their goals. Communicate with each team member often, and be friendly to each team member.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

Make a comment in the discord, either personal or group message, or communicate the issue during our group meetings.

**Goal-Setting, Planning, and Execution:**

1. Team goals for this semester:

Have each team member confident in their knowledge about the project and how the design will be executed in the second semester. Make sure everyone feels comfortable working with each other and communicates issues that arise.

2. Strategies for planning and assigning individual and team work:

Team members will be assigned tasks after team meetings based on their team role and skills which will then be recorded in meeting minutes.

3. Strategies for keeping on task:

    Having a checklist to complete items to do in a scheduled time.

**Consequences for Not Adhering to Team Contract:**

1. How will you handle infractions of any of the obligations of this team contract?

    We will bring it up during a meeting and discuss what has happened and collectively come up with a solution that satisfies everyone.

2. What will your team do if the infractions continue?

    If the infractions continue even after group involvement, we will notify our TA or Professor and will work off of their advice

**************************************************************************

a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*

b) *I understand that I am obligated to abide by these terms and conditions.*

c) *I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.*

| | |
|---|---|
| 1) Jonathan Kelly | DATE 9/16/21 |
| 2) Ricardo Ramirez | DATE 9/16/21 |
| 3) Adnan Salihovic | DATE 9/16/21 |
| 4) Noah Kelleher | DATE 9/16/21 |
| 5) Nathan McKay | DATE 9/16/21 |
| 6) Hengwei Chen | DATE 9/16/21 |

**THE TEAM**

**Team Members:**

| | |
|---|---|
| 1) Jonathan Kelly | 2) Nathan McKay |
| 3) Ricardo Ramirez | 4) Adnan Salihovic |
| 5) Noah Kelleher | 6) Hengwei Chen |

**Required Skill Sets for Your Project:**

Computer Engineers, Software Engineers, Electrical Engineers. We do not know any other requirements as of filling this form out.

**Skill Sets Covered by the Team:**

2 EEs (Ricardo and Hengwei), 2 CprEs (Noah and Nathan), 2 SEs (Jon and Adnan)

Nathan: Strong with low level coding and embedded systems concepts. Experienced with data sorting and parsing.

Noah: Embedded systems and security focus areas. Strong background with Android mobile development and Linux systems.

Adnan: Strong mid level knowledge of Python and C. Experienced with R and Python pandas for data visualization and analysis. Low level knowledge with embedded systems.

Ricardo: Experienced with C and embedded systems concepts. Low level knowledge with linux systems. Mid level experience with power.

Hengwei: good at low level coding and mathematics. Know a bit about c++ and python.

Jon: Experienced with Java, C, Python, Node.js, Linux, Junit testing and software system design.

**Project Management Style Adopted by the Team:**

Scrum and Agile, working within set time frames and planned meetings to meet smaller objectives using regular communication.

**Initial Project Management Roles:**

Team organization: Ricardo Ramirez

Client Interaction: Adnan Salihovic

Intercomponent : Hengwei Chen

Individual component design: Jonathan Kelly

Testing: Nathan McKay

Team communicator: Noah Kelleher