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


# System Requirements Specification
# CSE 4316: Senior Design I
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# Verminator
# Wasp Drone


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## Revision History

| Revision | Date | Author(s) | Description |
|---|---|---|---|
| 0.1 | 10.01.2024 | TN | document creation |
| 0.2 | 10.12.2024 | IM, LN, TN, NS, RY | complete draft |
| 1.0 | 10.14.2024 | IM, LN, TN, NS, RY | oficial release |
| 2.0 | 05.01.2025 | LN, TN, RY | Updated to reflect changing project requirements |

# Contents

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# 1 Product Concept

This section describes the purpose, use and intended user audience for the Wasp Drone product. Wasp Drone is a system that remotely exterminates wasp nests and other pests. Users of Wasp Drone will be able to safely exterminate wasp nests, spray venom, and remotely operate with a controller and live feed camera.

## 1.1 Purpose and Use

Wasp Drone will be sent in to neutralize wasp nests without the need for a human exterminator. The purpose of Wasp Drone is to provide a safe alternative for wasp extermination without putting exterminators in harm's way. Its venom delivery system can be modified to spray other liquids so there is versatility in agricultural applications (delivering insecticides, herbicides, fertilizer, and water). Wasp Drone's live feed feature can be used for filming and streaming applications as well.

## 1.2 Intended Audience

- Exterminators: The primary users for this product are wasp exterminators who would benefit from an efficient and safe solution to exterminating wasps and other pests.
- Property Owners: People with an infestation problem on their property(s) looking for an alternative to calling an exterminator.
- Farmers: Agricultural professionals looking to use the sprayer system for other applications on their products.
- Hobbyist: Anyone who intends to take our open-source product and modify it for their drone applications.

# 2 Product Description

This section provides the reader with an overview of Wasp Drone. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail.

## 2.1 Features & Functions

- Remote Controlled Flight: Controller operates vertical and horizontal drone flight. Programmed with PX4 software.
- Live Feed: Attached drone camera transmits live feed to Wasp Drone app(reach goal). 5.8 GHz radio transmission.
- Sprayer System: Refillable electronic pump keeps container pressurized. Remote-activated sprayer rod dispenses wasp venom.

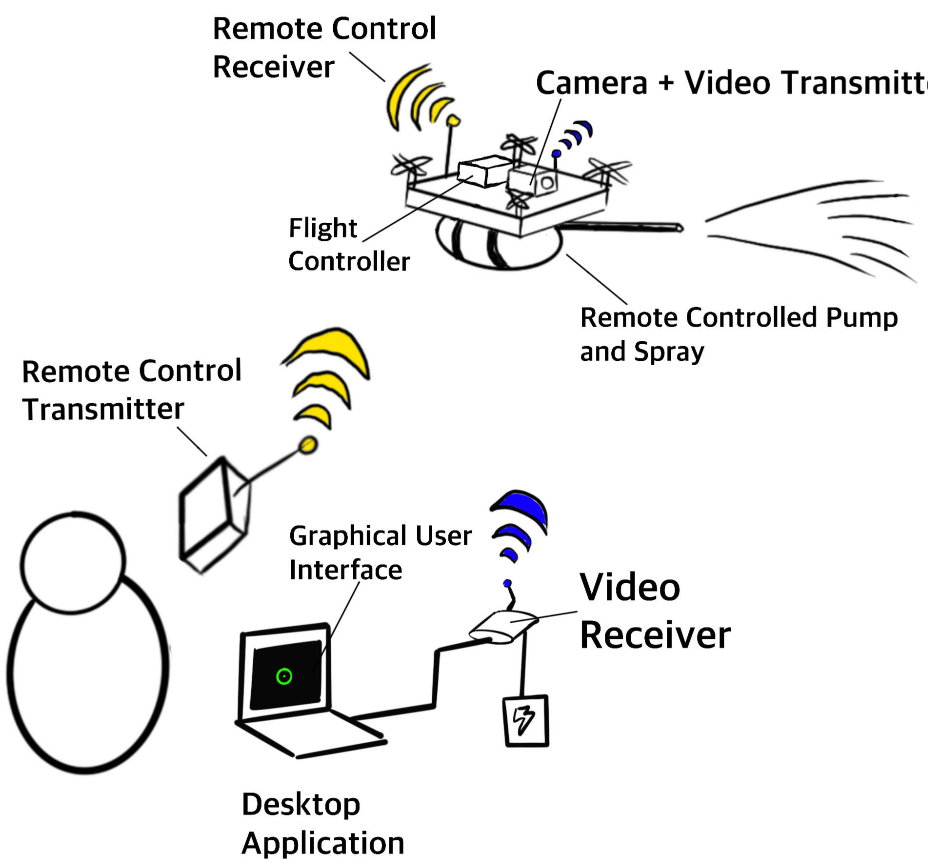


Figure 1: Product Concept of the Wasp Drone

### 2.2 External Inputs & Outputs

| Data Element | Description | Use |
|---|---|---|
| Flight Commands | User data that commands the drone. | Input: Controller input to man the drone. Vertical and horizontal movement. Drone speed. |
| Phone to Camera Connection(Reach Goal) | Radio connection from the phone to the drone camera | Input: Radio connection from user's phone to live feed camera. |
| Sprayer Activation | User data that controls sprayer | Input: Controller input that toggles the sprayer. |
| Live Feed | Camera footage | Output: Camera transmits live footage to the computer |

Table 2: Input Output Table

### 2.3 Product Interfaces

- Remote Controller: Hardware interface that operates the drone's flight, landing, and sprayer.
- Wasp Drone App UI(reach goal): A simple UI for the app that connects the user's phone to the drone

# 3 Customer Requirements

The following requirements detail usability and functional requirements specified by the project's sponsors, development team, and the intended audience. The customer requirements focus on usability and safety concerns. This is important because the drone will be used to disperse toxic chemicals, so systems must be robust, easy to use, and compliant with safety and environmental regulations.

## 3.1 Intuitive User Interface

### 3.1.1 Description

The drone will make use of standard remote controllers, a FPV camera, and an Android smartphone app(reach goal) to meet this requirement. Industry standard remote controllers will allow the user to pair any controller of their choice with our drone. FPV cameras will allow the user to aim the sprayer and provide vision in hard to reach locations. The drone will have compatible Android app(reach goal) to allow the user to receive live video feeds.

### 3.1.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington.

### 3.1.3 Constraints

Controls must account for several factors: 1) the drone must be easy and intuitive to control, 2) the user must be able to have a first-person view of the drone, 3) set up must be doable for inexperienced users within a reasonable amount of time.

### 3.1.4 Standards

Control systems must allow users to use standard controllers on 2.4 GHz signal and communicate with ground station using the MAVLink protocol.

### 3.1.5 Priority

Critical

## 3.2 Effective Operation in Day and Night Conditions

### 3.2.1 Description

It is typically recommended to remove wasp nests at night due to safety concerns and higher likelihood of encountering all members of the nest. Because of this, the user must be able to pilot the drone during the day and the night. This requirement is fulfilled with a FPV camera with high IR sensitivity. During the day, an additional IR filter can be mounted on the camera to improve daytime image quality. The drone must also meet required safety standards for night time operation including strobe lights and altitude locks.

### 3.2.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington.

### 3.2.3 Constraints

Must conform to strict budget.

### 3.2.4 Standards

Federal Aviation Administration (FAA) 14 CFR Part 107: Small Unmanned Aircraft Systems [2]

#### 3.2.5 Priority

Moderate

### 3.3 Refillable Insecticide Tank

#### 3.3.1 Description

The user must be able to refill the insecticide sprayer in an economical manner using liquid insecticides. A tank will allow for the user to refill using the liquid insecticide of their choice. May apply for exemption due to weight limit.

#### 3.3.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington.

#### 3.3.3 Constraints

Sprayer system packaging must be lightweight to operate drone in a safe manner. The tank must be securely fastened and sealed to protect the user and sensitive electronics.

#### 3.3.4 Standards

Federal Aviation Administration (FAA) 14 CFR Part 137: Dispensing Chemicals and Agricultural Products with UAS [1]

#### 3.3.5 Priority

High

### 3.4 Safely Dispense Toxic Chemicals

#### 3.4.1 Description

Agricultural drones are typically used to disperse pesticides, herbicides, and fertilizers. Because of this, our drone must comply with federal standards concerning the dispersal of toxic chemicals. Safety for the user and the environment is a major concern. May apply for exemption due to weight limit.

#### 3.4.2 Source

Development Team

#### 3.4.3 Constraints

Electronics will need to be protected. Sprayer system needs to be securely fastened. Sprayer system needs to be lightweight to meet weight limits for FAA regulations and to safely operate the drone.

#### 3.4.4 Standards

Federal Aviation Administration (FAA) 14 CFR Part 137: Dispensing Chemicals and Agricultural Products with UAS [1]

#### 3.4.5 Priority

Critical

### 3.5 Reliable Subsystems

#### 3.5.1 Description

The drone must be resilient. The mechanics of the drone and the toxic chemical payload poses a risk to the user and the environment. Features such as return to home and landing mode will need to be implemented and enabled in case of emergency situations. Another way to add reliability would be to implement redundant systems.

### 3.5.2 Source

Development Team

### 3.5.3 Constraints

Need to balance cost with redundancy and reliability. The team does not have the budget to build a fully redundant system, so failsafes need to be implemented instead.

### 3.5.4 Standards

None

### 3.5.5 Priority

Critical

## 3.6 Geofencing(reach goals)

### 3.6.1 Description

The FAA has strict safety definitions concerning airspace that drones and other unmanned aircraft systems (UAS) must abide by. For the safety of the user and external parties, geofencing systems will be implemented and interact with the onboard GPS module to enforce a strict airspace.

### 3.6.2 Source

Development Team

### 3.6.3 Constraints

The PX4 firmware needs to be modified to enforce stricter limits on the user to adhere to FAA regulation. Accuracy of the geofencing system is bounded by the capabilities of the drone's GPS module. The testing site must have allowable airspace to test this subsystem.

### 3.6.4 Standards

Federal Aviation Administration (FAA) 14 CFR Part 107: Small Unmanned Aircraft Systems [2]

### 3.6.5 Priority

Moderate

## 3.7 Thermal Imaging Camera

### 3.7.1 Description

Many wasps hide nests in hard to reach or hard to find locations, posing a hazard to unaware victims. Thermal imaging cameras are an optional solution to allow the user to locate hidden nests.

### 3.7.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington.

### 3.7.3 Constraints

Common thermal imaging cameras, such as those by FLIR, are prohibitively expensive. Existing FAA regulations need to be met and local laws regarding filimg, photographing, or observing people or objects from unmanned aircraft may prohibit testing of such a system.

### 3.7.4 STANDARDS

Federal Aviation Administration (FAA) 14 CFR Part 107: Small Unmanned Aircraft Systems [2]

### 3.7.5 PRIORITY

Low

# 4 Packaging Requirements

This project is designed to be modular and work with an entire ecosystem of parts and components. For example, the customer will have the option of purchasing a complete drone and sprayer, or be able to use the sprayer on a drone of their choice. To do so, our team will develop with industry standards in mind and keep our project open source.

## 4.1 Free and Open Source Software

### 4.1.1 Description

To facilitate future use of the drone project, source code and documentation will be made available for the open source community, drone enthusiasts, and will be licensed in a way to allow for commercial use cases.

### 4.1.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington, and the Development Team

### 4.1.3 Constraints

Software licensing must be permissive, allowing a wide range of use cases. Source code will need to be easy to follow and easy to use. Build guides will be provided for the user and similar hardware will be specified as known compatible options for the customer.

### 4.1.4 Standards

The PX4 Autopilot firmware is licensed under the 3-clause BSD license. It is a permissive license that allows for hobbyist and commercial use. Our additional modules will be licensed under the MIT License. The MIT License is also permissive and will allow for many use cases.

### 4.1.5 Priority

Critical

## 4.2 PX4 Autopilot Compatible

### 4.2.1 Description

PX4 Autopilot is an open source firmware package with autopilot and remote controlled capabilities. Building for the PX4 Autopilot system allows users who want to bring their own equipment to utilize our software. Additionally, our software can be added onto existing PX4 projects to provide more functionality.

### 4.2.2 Source

Development Team

### 4.2.3 Constraints

For budgeting reasons, we cannot test our firmware with all compatible flight controllers on the PX4 ecosystem. To ensure that our software is compatible, we need to follow strict adherence to the existing PX4 documentation and programming model.

### 4.2.4 Standards

PX4 Autopilot Documentation [3]

### 4.2.5 Priority

Critical

## 4.3 Software Distribution

### 4.3.1 Description

Our project will be both a product that can be purchased off the shelf, and as a firmware package that experienced developers and enthusiasts can integrate into their projects.

### 4.3.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington, and the Development Team

### 4.3.3 Constraints

A public code repository is necessary to enable developers and enthusiasts to use our software. Software delivered to customers would be included in the purchase of a drone. In this case, software will be flashed on the controller prior to sale.

### 4.3.4 Standards

MIT License

### 4.3.5 Priority

High

# 5 Performance Requirements

The wasp-killing drone is a product designed for a quick and efficient elimination of wasps in various environments. Performance is critical to ensure the drone can perform tasks with no delay, ensuring a quick response to wasp threats. The drone must operate within a specified time limits for key functions, including system initialization, takeoff, navigation,wasp detection and extermination. Operational efficiency is required to maintain a high level of effectiveness.

## 5.1 Wasp Detection and Elimination Time

### 5.1.1 Description

The user must be able to identify a wasp using the FPV camera(reach goal). There needs to be a low latency connection between the drone and the base station to facilitate a quick elimination time. The drone must stay in the air long enough to saturate the wasp nest with insecticide.

### 5.1.2 Source

Dr. Shawn Gieser and Dr. Chris McMurrough of the Department of Computer Science and Engineering, University of Texas at Arlington.

### 5.1.3 Constraints

The cost of the camera used to identify the nest and the overall cost of the drone and battery packs must be kept at a minimum due to the low budget.

### 5.1.4 Standards

IEEE 1233: system requirement specification
ISO 9126 - 1: Software Engineering - Product Quality
UL 3030: Unmanned Aerial Vehicles Safety Standards

### 5.1.5 Priority

High: The primary function and purpose is to eliminate wasps quickly and effectively.

# 6 Safety Requirements

The wasp-killing drone is designed to operate safely in residential and outdoor environments which ensures that is functionality does not harm users or nearby animals. The safety requirements ensure that the drone operates with established guidelines to prevent minimal injuries or exposure to harmful substances. The drone design will minimize risks by avoiding sharp components, restricting the use of hazardous materials and ensuring anything with electrical elements are shielded.

## 6.1 Propeller Safety Shielding

### 6.1.1 Description

All drone propellers will protected with safety shields(reach goal) to prevent accidental contact with users, pets or bystanders.

### 6.1.2 Source

CSE Senior Design laboratory policy

### 6.1.3 Constraints

The propeller safety shields(reach goal) must not interfere with the drones flight capability. The shield must be lightweight yet durable.

### 6.1.4 Standards

ASTM F2908: standard specification for consumer unmanned aircraft systems (UAS)

ISO 12100: Safety of Machinery - General Principles for Design

### 6.1.5 Priority

High

## 6.2 Non-Toxic Materials

### 6.2.1 Description

All materials used in the drone construction must be non-toxic and safe for human and animal exposure. The system must not release any harmful chemicals during operation.

### 6.2.2 Source

CSE Senior Design laboratory policy

### 6.2.3 Constraints

Materials used in the extermination system must be effective in killing wasps but must not pose a risk to people.

The use of toxins are prohibited, which limits the types of chemicals used

### 6.2.4 Standards

RoHS Directive 2011/65/EU on the restriction of hazardous substances

ISO 10993-5: Biological Evaluation of Medical Devices

### 6.2.5 Priority

High

## 6.3 Electrical Insulation

### 6.3.1 Description

All electrical components within the drone must be properly insulated to prevent shocks(reach goals). Wires should be secured and shielded to avoid exposure during operation.

### 6.3.2 Source

CSE Senior Design laboratory policy

### 6.3.3 Constraints

All wiring must adhere to insulation standards and be tested for durability during drone operation.

### 6.3.4 Standards

NFPA 70: National Electric Code (NEC)
IEC 60364: Low-voltage electrical installations

### 6.3.5 Priority

High

# 7 Security Requirements

The security requirement for the wasp drone project is to ensure secure operation of the drone and its components, the camera and the spray mechanism, without interference from any external sources.

## 7.1 Wireless Communication Security(reach goal)

### 7.1.1 Description

The drone will wirelessly communicate with a smartphone for camera feed and spray control. Although no data will be stored, securing communication between the drone and the smartphone is important to prevent unauthorized control. The live camera feed between the drone and the smartphone must be secured to prevent any privacy concerns and misuse of the video stream by any third party. The wireless control mechanism for operating the spray system also requires security to ensure safe and authorized communication.

### 7.1.2 Source

Team decision based on the system design.

### 7.1.3 Constraints

The wireless communication must operate within the drone's flight range. Security measures, such as encrypted communication (e.g., WPA2 or equivalent), can be considered to avoid unauthorized access or interference by external agents.

### 7.1.4 Standards

None specified at this stage.

### 7.1.5 Priority

High

# 8 Maintenance & Support Requirements

The requirements for maintaining and supporting the drone during the testing stage and the operating stage are as follows.

## 8.1 Drone Maintenance and Troubleshooting

### 8.1.1 Description

We have chosen a quadcopter design for the drone. As we add and integrate more components to our drone, maintaining the drone will become increasingly challenging and costly. Routine maintenance will involve swapping and recharging batteries as the batteries run out quickly when operating the drone. To ensure continuous operation, ideally, multiple batteries will be available for quick swaps. Additional maintenance will include replacing components that might get damaged during the testing phase and ensuring both hardware and software are functioning correctly. Troubleshooting can be guided by the schematics and flight controller documentation, and any system modifications can be made by referencing the schematic diagrams for necessary adjustments.

### 8.1.2 Source

The Orange Cube+ quick start guide.

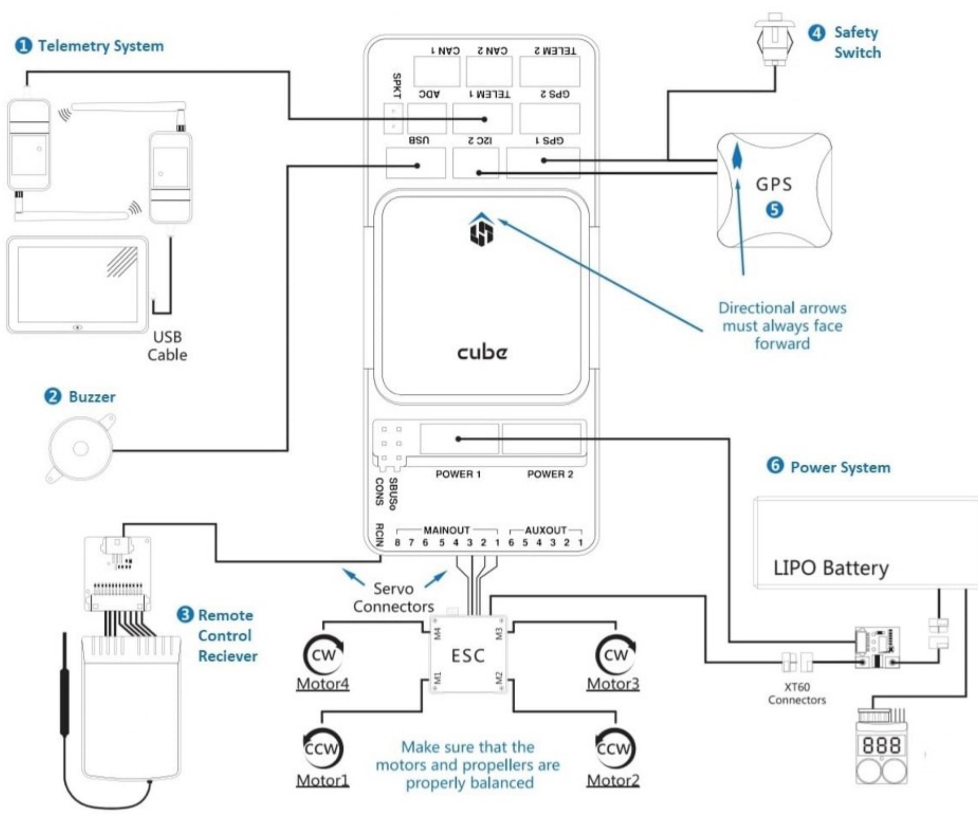


Figure 2: Wiring Overview (from Cube Orange+ Documentation)

### 8.1.3 Constraints

Complexity of the flight control system might become an issue among team members. Identifying errors and failures might also become challenging because of the team not having prior experience with

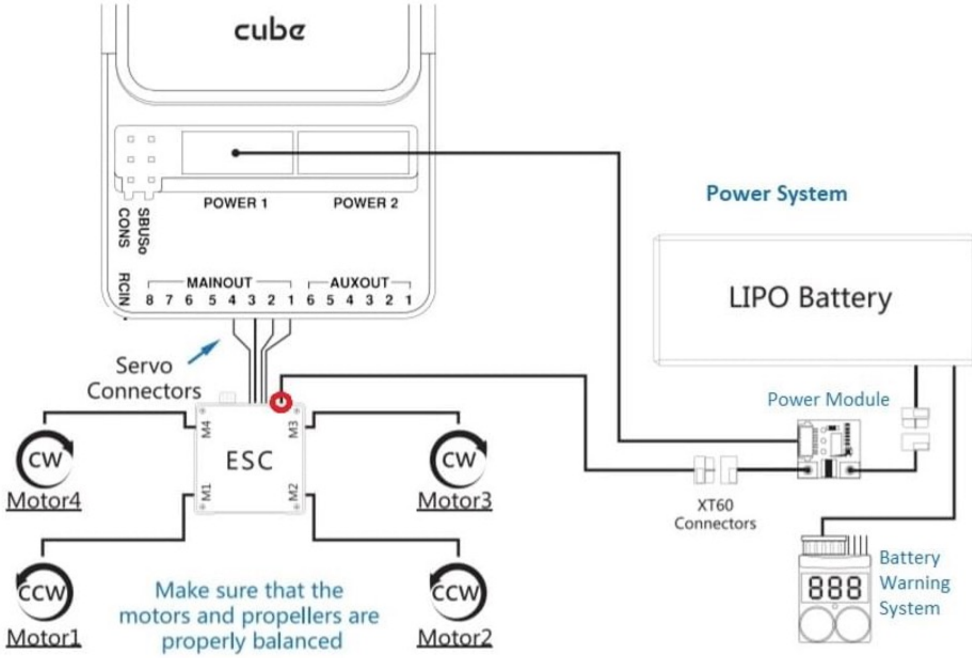


Figure 3: Power Systems Overview (from Cube Orange+ Documentation)

drones. Components like propellers, batteries, and the spray mechanism will require regular checks and potential replacements during the testing phase, which may lead to delays in operation and added shipping times for the replacements. Battery charging and swapping times will also impact the drone's operational availability. Additionally, budget constraints may arise due to the need for extra parts caused by possible failures during testing.

#### 8.1.4 Standards

PX4 software guidelines and Cube Wiring quick start.

#### 8.1.5 Priority

High

# 9 Other Requirements

## 9.1 Wasp Killing Drone Customization

### 9.1.1 Description

The Wasp Killing Drone project will be designed with future enhancements and customization capabilities to support various applications in targeting and eliminating wasp nests. This includes ensuring compatibility with additional expansion decks, sensors, and pesticide delivery systems to adapt to evolving project requirements. The team will also implement a video streaming system that provides real-time visual feedback for enhanced situational awareness during operations. These customization features will be integrated into the project's architecture during the development phase, allowing for new functionalities to be designed and tested.

### 9.1.2 Source

Project Sponsors: Dr. Gieser and Dr. McMurrough

### 9.1.3 Constraints

Customization may encounter constraints related to hardware limitations, compatibility issues with new components, and the need to maintain overall system stability. Thorough testing will be required to ensure that new additions do not adversely affect the drone's performance or safety. Given the delicate nature of the hardware, minimal intervention during handling and assembly is crucial to prevent damage.

### 9.1.4 Standards

No specific standards apply for this requirement.

### 9.1.5 Priority

Low

# 10 Future Items

## 10.1 Drone Assembly

### 10.1.1 Description

The drone assembly process will involve carefully assembling all ordered components, ensuring that they fit together properly and function as intended. This stage will include thorough checks for compatibility and safety before proceeding to the testing phase.

### 10.1.2 Source

Development Team

### 10.1.3 Constraints

Assembly must adhere to manufacturer specifications and safety guidelines to avoid damage to delicate components.

### 10.1.4 Standards

ASTM F2910-14: Standard Guide for the Evaluation of the Safety of Small Unmanned Aircraft Systems

### 10.1.5 Priority

Critical

## 10.2 Manual Control

### 10.2.1 Description

The drone shall be controlled manually using a controller which allows operators to navigate freely and respond dynamically to obstacles.

### 10.2.2 Source

Sponsors

### 10.2.3 Constraints

Operators must maintain awareness of environmental conditions and obstacles while controlling drone manually.

### 10.2.4 Standards

No specific standards apply to this requirement.

### 10.2.5 Priority

Critical

## 10.3 Camera and Video Streaming

### 10.3.1 Description

The Wasp Killing Drone will be equipped with a camera and a video streaming application to facilitate real-time obstacle detection and navigation during operations.

### 10.3.2 Source

Sponsors

#### 10.3.3 Constraints

The video streaming system must operate effectively under varying environmental conditions and maintain a stable connection for real-time feedback.

#### 10.3.4 Standards

No specific standards apply to this requirement.

#### 10.3.5 Priority

Critical

### 10.4 Pesticide Application System

#### 10.4.1 Description

The drone shall integrate a pesticide application system to deliver pesticides precisely to targeted wasp nests without affecting surrounding environments.

#### 10.4.2 Source

Sponsors

#### 10.4.3 Constraints

The pesticide system must comply with safety regulations regarding pesticide use and ensure environmental protection measures are in place.

#### 10.4.4 Standards

EPA regulations on pesticide application.

#### 10.4.5 Priority

Critical

### 10.5 Documentation

#### 10.5.1 Description

Comprehensive documentation, including user manuals, pesticide application guidelines, setup guides, and troubleshooting instructions(some reach goals), will be provided in both digital and printed formats for ease of access.

#### 10.5.2 Source

Sponsors

#### 10.5.3 Constraints

Documentation must be clear, concise, and easily understandable, accommodating users with varying technical expertise.

#### 10.5.4 Standards

None

#### 10.5.5 Priority

Critical

## 10.6 Communication Reliability

### 10.6.1 Description

Communication reliability refers to the dependability of the communication system between the Wasp Killing Drones and the central control system (ROS). A highly reliable communication system ensures seamless data exchange and coordination within the drone swarm, which is essential for maintaining situational awareness and executing maneuvers without interruptions or data loss during pest control operations.

### 10.6.2 Source

Development Team

### 10.6.3 Constraints

Limitations imposed by communication protocols, signal interference, or environmental factors affecting wireless communication performance.

### 10.6.4 Standards

MAVLink Protocol. FCC defined 2.4 GHz and 5.8 GHz bands

### 10.6.5 Priority

Critical

## 10.7 Operation Speed

### 10.7.1 Description

Operation speed refers to the ability of the Wasp Killing Drone to execute commands and respond to inputs rapidly and efficiently. This capability is crucial for tasks such as trajectory planning and communication between drones, allowing it to operate swiftly. In dynamic environments, such as pest control missions, operational speed enables the drones to adapt to new information and maintain situational awareness in real-time, enhancing their effectiveness in locating and targeting wasp nests.

### 10.7.2 Source

Development Team

### 10.7.3 Constraints

Limitations imposed by hardware capabilities, communication bandwidth, and environmental factors affecting drone performance.

### 10.7.4 Standards

Industry benchmarks for response times in a controlled environment.

### 10.7.5 Priority

Critical

## 10.8 Fault Tolerance(reach goals)

### 10.8.1 Description

Fault tolerance refers to the Wasp Killing Drone swarm system's capability to withstand and mitigate the impact of individual drone failures or malfunctions. Robust fault tolerance capabilities are essential to minimize the impact failures and ensure continued operation and mission effectiveness. In the event of catastrophic failures, failsafes must be implemented to reduce environmental harm, bodily injury, and loss of the drone.

### 10.8.2 Source

Development Team

### 10.8.3 Constraints

Limitations imposed by hardware and communication protocols for fault detection and recovery. Low budget limits how much redundancies can be implemented.

### 10.8.4 Standards

FAA 14 CFR Part 107

### 10.8.5 Priority

Critical

## References

[1] Department of Transportation Federal Aviation Administration. 14 CFR Part 137, 1965 ammended 2018.

[2] Department of Transportation Federal Aviation Administration. 14 CFR Part 107, 2016.

[3] PX4. PX4 Guide (Main), updated 2024.